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РЕЗЮМЕ

ИЗУЧЕНИЕ КОМПОНЕНТОВ ДИУРЕТИЧЕСКОГО ФЕНОЛЭФИРА ПЕТРУШКИ. I

Г. МАРЦАЛ, М. БАЛОГ, Г. ВЕРЗАР-ПЕТРИ

Апиол и миристицин были изучены в экстракте из корня, листьев и семян у растений **Petroselinum hortense var. longum**, широко культированного в Венгрии, разными хроматографическими методами, и также использованием физических постоянных, с особым учетом онтогенеза. Установили значительное колебание и постепенное обогащение двух химических соединений в настоящем листе к концу вегетационного периода первого года.

ДАННЫЕ ОБ ИЗМЕНЕНИИ СОДЕРЖАНИЯ ЦИАНИСТОГО ВОДОРОДА У СУДАНСКОГО (SORGUM SUDANENSE) И У ТЕХНИЧЕСКОГО СОРГО (SORGUM BICOLOR VAR. TECHNICUM) ВО ВРЕМЯ ВЕГЕТАЦИОННОГО ПЕРИОДА

Й. ВЕТТЕР, Е. ХАРАСТИ

В нашем опыте содержание цианистого водорода было определено у некоторых сортов сорго (**Sorgum**) с начала прорастания до фазы цветения. В опыте исследовались следующие сорта: **Sorgum sudanense, Hybar Mv 301, Hybar BB 7301, Hybar BB 7302, Szarvasi 350, SzC 40, Sorgum bicolor var. technicum.** Содержание цианистого водорода семян, проростков и листьев 21—124-дневных растений определялось с помощью микрометода пикриновой кислоты, модифицированным для анализа маленьких проб. Параллельно с этим было определено и изменение сухого вещества. На основании проб, взятых в десять сроков, было установлено, что семена изученных растений содержат очень мало цианистого водорода, в одном случае даже не были обнаружены следы. Очень интенсивное повышение уровня цианистого водорода было обнаружено на четвертый день прорастания, когда проростки находились в стадии быстрого, продольного роста. В более поздних периодах вегетативного роста (21 и 35-дневные) был зафиксирован постепенно понижающийся уровень цианистого водорода в каждом изученном растении. Далее, в период до цветения уровень цианистого водорода — с некоторыми колебаниями — продолжал снижаться. У большинства сортов данные самых последних проб оказались самыми низкими. По существу сходная тенденция обнаружена у всех семи изученных сортов и гибридов.

МОРФОЛОГИЧЕСКИЕ ПРИЗНАКИ ИНТЕРАКЦИИ И КЕЛАТНЫЕ КОМПЛЕКСЫ МИОЗИНКОНТАКТНЫХ АМИНОКИСЛОТ С АТР. (ДОКАЗАТЕЛЬСТВО СУЩЕСТВОВАНИЯ ЦИСТЕИН-ГИСТИДИН И ЦИСТЕИН-АТР КОМПЛЕКСОВ)

И. ОВАРИ, Ш. ФАЗЕКАШ, В. СЕКЕШШИ-ХЕРМАНН, И. КОБОВИЧ, П. ЮХАС

Опыты были выполнены для того, чтобы подтвердить флуоресцентное подавление интеракции АТР и келатных комплексов (Фазекаш и др. 1976), и участие контактных аминокислот в ферментативной активности миозина. Приведено значительное количество доказательств, показывающих, что в то время как интеракция и келатные кристаллы развиваются, они имеют разный морфологический вид и изменяющуюся или устойчивую

анизотропию. Это показывает, что кристаллы различаются по их качественным признакам и также по форме и размерам. Результаты подтверждают не только существование АТР комплексов, но и существование интеракции АТР-цистеин, цистеин-гистидин и АТР-цистеин-гистидин и келатных комплексов, которые, повидимому, надо рассматривать как первичные промежутки на активном участке миозина.

ПРОДУКТИВНОСТЬ НЕКОТОРЫХ ГЕНОТИПОВ ЛЮЦЕРНЫ В УЗКО- И ШИРОКОРЯДНЫХ ПОСАДКАХ. II. ОТБОР РОДИТЕЛЬСКИХ КЛОНОВ В УСЛОВИЯХ ПРОМЕЖУТОЧНЫХ ПОСАДОК

А. И. РАММАХ, З. БЭЙТЭШ

Стеблевые черенки полуродственных растений были отселектированы в широко-, промежуточно- и узкорядных посадках у четырёх генетически различных типов люцерны и пересажены в две посадочные системы. Материалы были случайно распределены внутри повторности таким же образом в двух посадочных системах. Генотипическая и фенотипическая изменчивость, выраженная как генетическая и фенотипическая ковариансa, были выше в узких посадках, чем в широких посадках. Порядок исследованных генотипов был явно различный в двух посадочных системах. Урожай сухого вещества был наименее устойчивым признаком, а высота растений наименее чувствительным признаком в условиях конкуренции. Отселектированные генотипы эректоидных и полуэректоидных типов из широкой посадки были лучшими, когда исследовались в широкой посадке, но были наихудшими, когда изучались в узкой посадке. Отборы стелющихся и полустелющихся типов из широкой посадки дали более высокую урожайность в широкой посадке. Число стеблей и толщина были наиболее важными факторами, влияющими на продуктивность отобранных генотипов в промежуточном питомнике, когда они пересаживались в ряды, т. е. в условия коммерческого производства.

ИЗУЧЕНИЕ ОБЕСПЕЧЕННОСТИ АМИНОКИСЛОТАМИ ПОРОСЯТ ПОРОДЫ «ХУНГАХИБ»

Й. ЕЧАИ, М. СЕЛЕНИ-ГАЛАНТАИ, Б. ЮХАС

Потребность в лизине у венгерской белой свиньи мясного типа и свиньи «Хунгахиб» была изучена в групповом опыте по определению азотооборота. Установлено, что свинья венгерской белой породы мясного типа на первой стадии откармливания нуждается в 0,8% лизина в зависимости от содержания белка корма, но на поздней стадии откармливания ей достаточно и 0,6%. Потребность в лизине у свиньи «Ахиб» в случае кормовой смеси сходного состава более высокая: даже выше, чем 1,0%. Между азото-ретенционными величинами, полученными в ходе опытов по изучению азотооборота, и содержанием лизина кровяной плазмы были найдены математические связи. Корреляция между содержанием свободных аминокислот кровяной плазмы и азоторетенционными величинами $r = 0{,}8268$ между содержанием лизина корма и азоторетенцией $r = 0{,}9716$. Подобная интенсивная связь была обнаружена между содержанием лизина, усвоенного с кормом, и содержанием лизина кровяной плазмы, где $r = 0{,}8865$.

NON NOBIS SOLUM NATI SUMUS
(CICERO, DE OFFICIIS 1, 22)

This issue of our journal is respectfully dedicated to the memory of Prof. György Mándy, esteemed preceptor of

the Managing Editor

Acta Agronomica Academiae Scientiarum Hungaricae, Tomus 26 (1—2), pp. 3—5 (1977)

GYÖRGY MÁNDY

1913—1976

Professor György Mándy, head of department at the Debrecen Agricultural University, doctor of the biological sciences, world famous ecologist of cultivated plants, an outstanding representative of variety taxonomy and an eminent researcher on the origin of agricultural plants, a leading personality in the teaching of agricultural botany, died on 30th May 1976, at the age of 63.

He was born in Budapest on 29th August 1913 and qualified as a secondary school teacher in 1935. Even before receiving his diploma he decided to devote his life to studying the varieties of cultivated plants, and began his work of making observations, collecting data and carry out experiments for variety comparison at the institute of Prof. Zoltán Szabó. Zoltán Szabó's general botanic and genetic experimental work, his perception of problems, sense of vocation, and sense of values, which was rooted in the humanity of his rich personality, served as a constant example to him. He carried out educational and research work with extreme diligence and enthusiasm, and with a deep sense of vocation, and already in the early years found many followers among the young and gained many friends among his elder colleagues. Owing

to his outstanding sense of professional vocation, his thorough botanic knowledge and exceptionally widely based biological interest he was appointed at a comparatively young age as lecturer in the Botany Department at the College of Horticulture (now the University of Horticulture).

Within a short time he wrote a text-book on horticultural botany, then, with a co-author, another one on the plant breeding aspects of genetics. He attached great importance to plant physiology as the theoretical basis of horticulture and published lecture notes on this subject too. He started a periodical on the subject of agricultural botany. He organized the instruction in this elementary subject at a high level, and because of his professional bias, which was rooted in his love of vocation, he was the maximalist type of lecturer, and his wide and thorough knowledge made him a strict teacher.

Later he continued his scientific work at the Tobacco Research Station in Érd, on a firm theoretical basis of agricultural botany and in a programme of practical importance. He carried out the comparative evaluation of tobacco varieties with regard to their active substance production and ecology, working mostly with Hungarian varieties, but also with many foreign varieties of outstanding importance. His studies on the taxonomy and ecology of tobacco varieties provided many data, on which he grounded a new conception of the ecology of cultivated plants. He continued this programme on a considerably wider scale at the Botanical Research Institute of the Hungarian Academy of Sciences, Vácrátót, and at the Research Institutes and Experimental Farms of the Ministry of Agriculture. Data from sites in different regions further deepened his view of plant ecology and his attitude towards the evaluation of cultivated varieties. His work here took a new direction in the launching of the "Kulturflóra" series: he was the writer, editor and organizer of many volumes. His professional enthusiasm was boundless, nothing could impede his activity; he always managed to find time to discuss professional topics and to talk them over with his students; he was always sorry when these discussions came to an end and never tried to hurry them. He was never short of time, and completed his daily work quota in the evening, at night, or in the early hours of the morning under the stimulus of mental pleasure. His extensive correspondence and professional writing were done at night, untiringly. His creative rhythm was inimitable, though his students and friends were greatly inspired by his example.

At the Research Institute of South-East Transdanubia in Iregszemcse, and later at the Institute of Agrobotany in Tápiószele he brought the varietal taxonomy, ecology and productivity of cultivated plants to perfection, and established a school with the participation of many of his students. He developed the methodology of staggered sowing and made it suitable for the ecological evaluation of varieties and for an objective classification by means of mathematical formulae. By introducing the ecological index he gave a theoretical

explanation of the importance of the variety from the point of view of yield reliability, and determined experimentally the optimum sowing time of the varieties by characterizing it with the shortest flowering period. This proves the role of endogenous factors during the early stages of development in inducing interactions between ecological factors. In his new interpretation of the concept of field resistance he pointed out that pathological resistance is the direct consequence of the joint effect of optimum ecological conditions. He supplied convincing evidence that the degeneration of a variety and the genetic change taking place in varieties are in close correlation with the selective role of the ecological fators, and this modern viewpoint led to the realization that the varieties, types, progenies and lines of cultivated plants can best be preserved by storing them in such a way that their germinating ability is maintained, since repeated sowing transforms the variety by sorting out certain types.

His appointment to the Chair of Botany and Plant Physiology at the Debrecen Agricultural University gave him great pleasure, because besides widening the scope of his research work he got involved in the education of young people. His high sense of vocation made him an enthusiastic teacher and his zeal often led him to expect too much of his first-year students, thus causing a certain amount of tension. But nothing could sap his energy and activity. He wrote text-books, organized conferences and arranged cultural programmes. Besides yield reliability he always kept in mind the necessity of increased productivity, and therefore considered agricultural chemization to be indispensable, but he was a strong critic of the excessive use of chemicals, being aware of the need for agricultural environmental protection.

Mándy regarded the propagation of knowledge as an extremely important task, and as the head of the Hajdú-Bihar county section of the Society for the Dissemination of Knowledge (TIT) he took an active part in cultural programmes. As a member of the permanent committee of the Botanical Section he encouraged the debating spirit, and always gave an enthusiastic account of his latest results, opinions and working hypotheses. As the leader of the Tessedik Socialist Brigade he worked untiringly in applying theoretical knowledge to practical production work, carried away by his sense of vocation and his love of science.

His spiritual concentration, unparalleleddiligence, exemplary sense of vocation and unprecedented capacity for work will remain alive in the desire of his students and friends to serve the sciences, and in the memory of those who carry out research in the field of plant ecology.

B. I. Pozsár

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PHENOL-ETHER COMPONENTS OF DIURETIC EFFECT IN PARSLEY, I

By

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In root, leaf and fruit extracts of *Petroselinum hortense* var. *longum*, which is widely cultivated in Hungary, apiol and miristicine were studied with various chromatographic methods and by measuring the physical constants, with special regard to ontogeny. The two compounds were found to show a considerable fluctuation and gradual enrichment in the foliar leaves by the end of the first year of vegetation.

Introduction

A considerable part of the Umbelliferous plants grown in Hungary have a well-known therapeutic effect. Parsley, for example, is used as a diuretic or folk medicine in the popular medicine (WEISS 1960, BRAUN 1968). The diuretic effect is due to the volatile oil which has two bioactive components: apiol and miristicine (Fig. 1). Both are compounds of the phenol-ether type. Apiol is still active at a 6 : 100,000, miristicine at a 1 : 100,000 dilution. Considering that the amount of these compounds varies with the different organs and cultivated varieties, not all the volatile oils are used in therapy, as pointed out by Stahl and Jork, who examined the oil from different origins in Europe and found that certain oils are richer in apiol and others in miristicine (STAHL–JORK 1964).

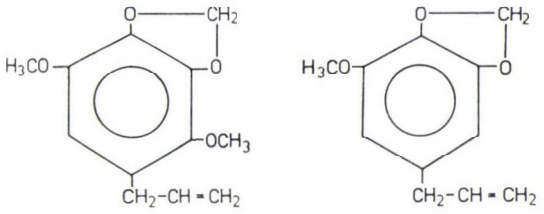

Fig. 1. Formulae for apiol and miristicine

Material and Method

First we examined the physical and chemical constants of volatile oil placed at our disposal by the Szilasmenti Co-operative Farm and of another oil which we produced ourselves according to the prescriptions of the Hungarian Standard, and measured their apiol

and miristicine contents by the method of Thoms—Rosenthaler (KARMAZIN 1955). In producing volatile oil by vapour distillation we used the roots, leaves and fruits of *Petroselinum hortense* var. *longum* which we grew ourselves.

Changes in the main active substances of plants during ontogenesis were followed in serial tests. *Petroselinum hortense* var. *longum* plants were grown in sandy soil at Pestlőrinc. From the plants sown in the second half of April samples were taken two weeks after sowing, then every two weeks successively. The plant material was separated into organs and dried at room temperature. Petroleum-ether (b. p. 40—70°C) extracts were prepared from the drug using Soxleth apparatus. The apiol and miristicine contents of the extracts were examined by thin-layer chromatography using silica gel—G (Merck) as absorbent and benzol as a solvent system (STAHL 1962), with the aid of test materials. On the slides, developed with phosphoric molybdenum acid, colour intensity was measured by densitometry (SCHRATZ—QUADRY 1966). The main components were eluated from a preparative thin layer. The isolated substances were identified on the basis of m.p. (apiol: 30°C) and refraction index (miristicine: 1.54). The purity of the substances was examined with various methods of thin-layer chromatography and checked by gas chromatography. Solvent systems used for contra processes were benzol, benzol–ethyl–acetate 90 : 10, chloroform–benzol 75 : 25 and petroleum–ether 95 : 5.

Gas-chromatographic analyses were carried out in a Jeol JGC 1100 apparatus with flame ionization detector, using parameters different from those known so far in the literature (STAHL—TRENNHEUSER 1960; WAGNER—HÖLZL 1968). Sensitivity was 4.10^{-10}. The 1 m long, 3.8 mm inner diameter glass column contained Chromosorb W packing material moistened with 2 per cent OV—1, the carrier gas was N_2. The incoming pressure of the carrier gas was 0.7 kp/cm², the injector temperature 180°C, the detector temperature 240°C. The volume of the input sample was 0.5 μl. Paper speed was 0.5 cm/minute.

Results

The examination of freshly distilled volatile oils for physical and chemical constants covered optical rotation, refractive index, specific gravity, solubility (in 95% alcohol), the acid and ester numbers as well as ester number after acetylation (Table 1).

Table 1

Physical and chemical constants of volatile oil in parsley

	Density	Refractive index	Optical rotation	Acid number	Ester number	Ester number after acetylation	Solubility in 90% alcohol
Seed oil, own (prescription of the Hungarian Standard MSz 14533—73)	1.060	1.513	—8.2°	1.8	5.4	34.2	1+8
	1.031—1.103	1.512—1.528	—4°—10°	up to 5	1—11	4—20	1+(4—8)
Leaf oil, own (prescription of the Hungarian Standard MSz 14532—73)	0.883	1.504	—2°15′	2.3	10.3	37.8	1+8
	0.898—1.000	1.500—1.526	+1°—4°	max. 1	5—14	15—40	1+(2—4)

In the course of gas-chromatographic studies the retention temperatures of isolated apiol and miristicine were established under programmed conditions

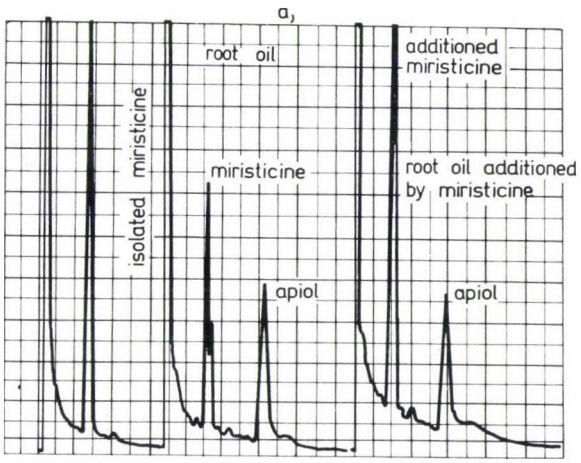

Fig. 2a. Gas-chromatogram of isolated miristicine and parsley root oil; demonstration of miristicine in root oil by addition

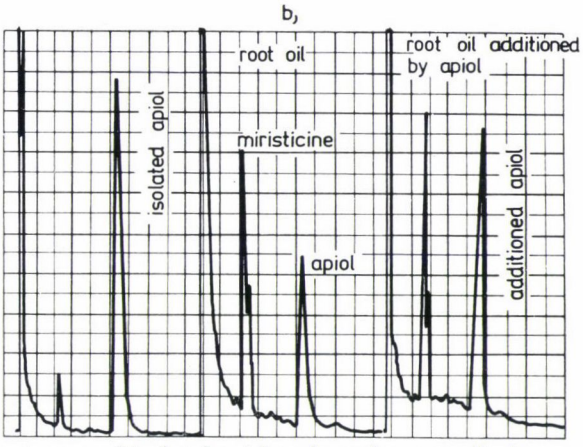

Fig. 2b. Gas-chromatogram of isolated apiol and parsley root oil; demonstration of apiol in root oil by addition

(Table 2). By adding isolated apiol and miristicine the apiol and miristicine contents of the parsley root oil were identified and their ratio established (Figs 2a and 2b).

Table 2

Gas-chromatographic parameters

	Gas-chromatographic parameters	
	R_f	R_t
Apiol	120°C	5.1 minutes
Miristicine	140°C	11.6 minutes

By evaluating the oil content of the leaf we have arrived at the conclusion that myristicine and apiol are contained in the leaf oil in equal quantities. Myristicine was found to be the main component of the fruit oil (Fig. 3).

Fig. 4 shows the comparative gas-chromatogram of root and leaf extracts obtained from the material which we grew ourselves. Apiol and myristicine are found in the root at a ratio of 1 : 1, while in the leaf there is about ten times as much miristicine as apiol. Figs 5 and 6 show the results of thin-layer chromatography for the two main active substances at different times of collection.

Fig. 7 gives an account of changes in the apiol and myristicine contents during ontogenesis.

At the beginning, only miristicine can be observed in the leaf extract. Its quantity gradually increases during the vegetative period, reaches a maxi-

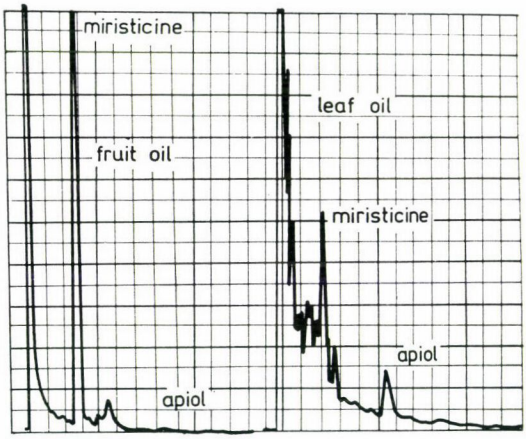

Fig. 3. Comparative gas-chromatogram of leaf oil and fruit oil

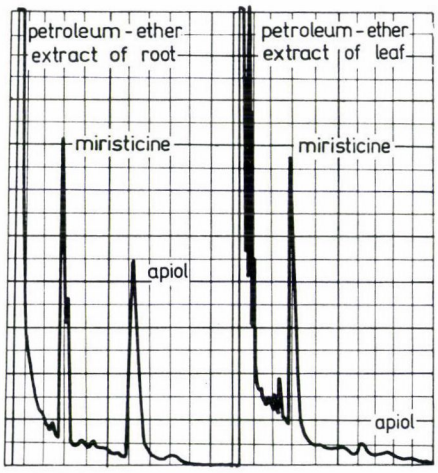

Fig. 4. Comparative gas-chromatogram of root and leaf extracts

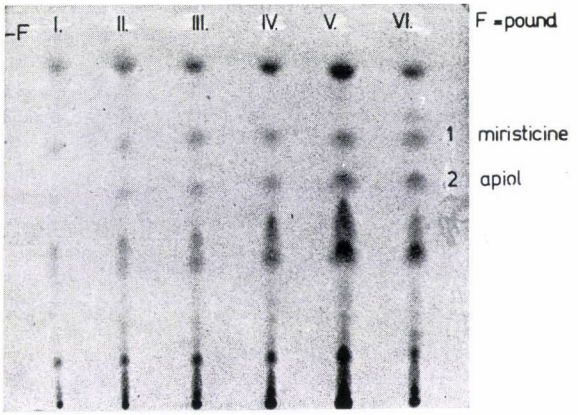

Fig. 5. Demonstration of apiol and miristicine by thin-layerchromatography in root oil obtained at different sampling times

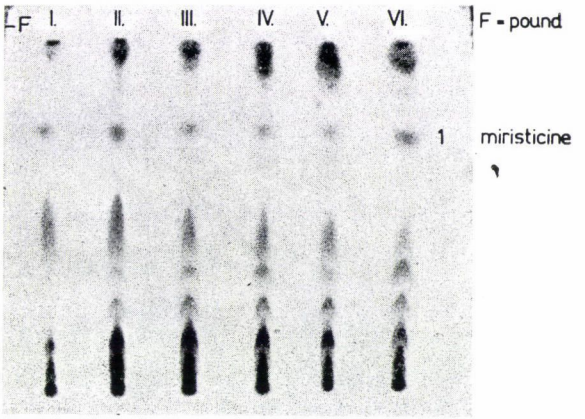

Fig. 6. Demonstration of apiol and miristicine by thin-layerchromatography in leaf oil obtained at different sampling times

mum on the seventh occasion of sampling (first week of August), then falls below the initial level, indicating the autumn state of dormancy, which is not followed by any morphological change in the first year. Apiol first appears in a demonstrable quantity on the fourth occasion of sample collecting. Its quantity increases evenly, reaching the maximum likewise on the seventh occasion of sampling, remains at this level in sample VIII, then decreases.

Of the two phenol-ether type compounds, apiol shows an increasing tendency in the root as well, while miristicine decreases from the initial high level, reaching a minimum in samples IV and VII. In the eighth sample the two compounds are at the same level, then their quantities suddenly fall.

Comparing the diagrams of leaf and root, we find that on the seventh occasion of sampling, in the first week of August, when the plants are at the stage of full development, the active substances accumulate in the leaf, while their quantities reach a minimum in the root.

By the end of the vegetative period the quantities of the two compounds in the root — which overwinters — decrease, while in the leaf — probably in

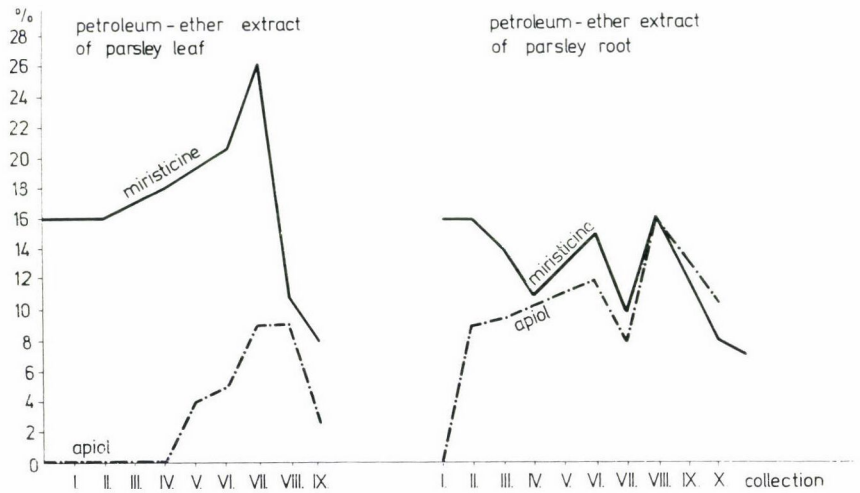

Fig. 7. Changes in apiol and miristicine contained in leaf and root oils during ontogenesis

connection with assimilation — they increase until the destruction of the foliage occurs at the end of the summer. Their relative parallel trend suggests that there is no antagonistic relation between them, which is important from the point of view of a possible chemical selection. Further registration of changes in their quantities during the vegetative period may provide the possibility of planning the quality of oil and carrying out yield calculations.

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CHANGES IN THE HYDROGEN CYANIDE CONTENT OF SUDAN GRASS (SORGHUM SUDANENSE) AND BROOMCORN (SORGHUM BICOLOR VAR. TECHNICUM) DURING THE GROWING SEASON

By

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Changes in the hydrogen cyanide content from the beginning of germination to the phase of flowering were determined in some *Sorghum* plants. The varieties included in the experiment were: *Sorghum sudanense*, Hybar Mv 301, Hybar BB 7301, Hybar BB 7302, Szarvasi 350, SzC 40 and *Sorghum bicolor* var. *technicum* Szegedi 425–70. A modified picric acid micro-method suitable to analyse small numbers of samples was used to determine the hydrogen cyanide content in the seeds and leaves of seedlings and 21—124 days old plants; changes in the dry matter content were measured parallel. On the basis of samples taken on ten occasions we found that the seeds of the examined plants contained but very small quantities of hydrogen cyanide; in one of the cases it could not be pointed out even in traces. A very intensive increase of the HCN level was observed on the fourth day of germination, when the seedlings were in the phase of a rapid longitudinal growth. In later phases of vegetative development (on the 21st and 35th days) the hydrogen cyanide level gradually decreased in all experimental plants. In the subsequent period — up to the stage of flowering — the hydrogen cyanide level showed a further decrease, though with some fluctuation. The values obtained on the last occasion of sampling were found to be the lowest in most varieties. In essentials, the same tendency was observed in all the seven examined varieties and hybrids, respectively.

Introduction

The study of plants containing cyanogenic glycosides has recently come into the limelight again. This is proved by the investigations aimed at clarifying the biosynthesis, accumulation and genetic problems of this group of compounds considered as secondary metabolic products, their distribution among the plant parts (NASS 1972, WOLF—WASHKO 1967), the polymorphism of cyanogenesis (JONES 1973), as well as the different ways of decomposition of these compounds (LOYD *et. al.* 1971, WATTENBERGER *et al.* 1968). Beyond the plant physiological importance of the question the subject is made interesting by plant breeding, genetical and toxicological aspects as well. A considerable — and justified — attention has been paid e.g. to the cyanogenic glycosides of *Manihot esculenta*, a major calorie carrier for nearly four hundred million people, as pointed out at a scientific conference held in London in 1973 (NESTEL—MCINTYRE 1973).

On the basis of extensive investigations we know that cyanogenic glycosides have so far been found in nearly 1000 plant species most of which belong to the families *Passifloraceae*, *Gramineae* and *Leguminosae* (TAPPER—REAY

1973). Similar data were published in an earlier paper of ours (HARASZTI—TÖLGYESI 1966). Besides the data of chemotaxonomic importance — mostly referring to *Lotus* and *Trifolium* species — not much has been done to follow the quantitative correlations between the development phase and the cyanogenic glycoside content of the plants. Considering the unreliability of the methods used so far to point out and determine quantitatively the cyanogenic glycosides, one of our purposes was to elaborate a reliable micro-method. In possession of this method a further aim was to carry out comparative studies on some *Sorghum sudanense* varieties on the basis of samples taken in different phases of development.

Material and method

The plants included in our investigations were: *Sorghum sudanense*, Hybar Mv 301, Hybar BB 7301, Hybar BB 7302, Szarvasi 350, SzC 40, *Sorghum bicolor* var. *technicum* Szegedi 425—70. The initial phase of germination was studied on seeds germinated in Petri-dishes kept in dark at 26°C; the plants were grown from seed in culture pots under the usual glasshouse conditions.

The cyanogenic glycoside content was characterized by the quantity of CN^- released during the enzymatic (glycosidase) hydrolysis. The theoretical basis of our method was provided by the colour reaction of CN^- and picric acid (SNELL—SNELL 1959). Determination was carried out in the following way: aliquot (150—200 mg) samples of seeds and leaves of seedlings and developed plants, respectively, were homogenized with distilled water in a mortar, or with a Potter—Elvehjem type homogenizer, with constant cooling. HCN was released then occluded in picric acid in a system immersed in water bath and supplied with CO_2-free air current. Determination was carried out at 52°C for 30 minutes. The carbon dioxide content of the air was occluded by 20 per cent KOH or 10 per cent $Ba(OH)_2$. The occlusion of HCN was carried out by 10 ml alkaline solution of picric acid (2.28 g picric acid in 1 litre 0.25 N NaOH). The colour of picric acid against the CN^--free solution prepared under similar conditions was measured at 480 mμ by a Spektromom 361 type spectrophotometer. The CN^- content was calculated from the obtained extinction values on the basis of a calibrating curve prepared in the above system. For standard material we used KCN; HCN was released from its freshly made solution with 3 N HCl.

The obtained data are given in μg CN^-/g fresh weight, μg CN^-/g dry weight unit; the plant samples are characterized by the arithmetical mean ($\bar{x}$) and standard deviation (s) of the data (SVÁB 1973).

Results

In our experiment changes in the cyanogenic glycoside content during germination and the vegetative development were followed on the basis of the released HCN content. According to our data (Table 1, Figs 1 and 2) seeds of various *Sorghum sudanense* varieties contained but little HCN; the measured values ranged between 2.15 and 33 μg/g seed. In the seeds of *Sorghum bicolor* var. *technicum* not even traces of hydrogen cyanide were found. Metabolic processes starting with germination did not cause considerable changes in the first 24 hours in the CN^- content either; our data ranged between 0 and 22 μg/g fresh weight. The next occasion of measuring was on the 4th day

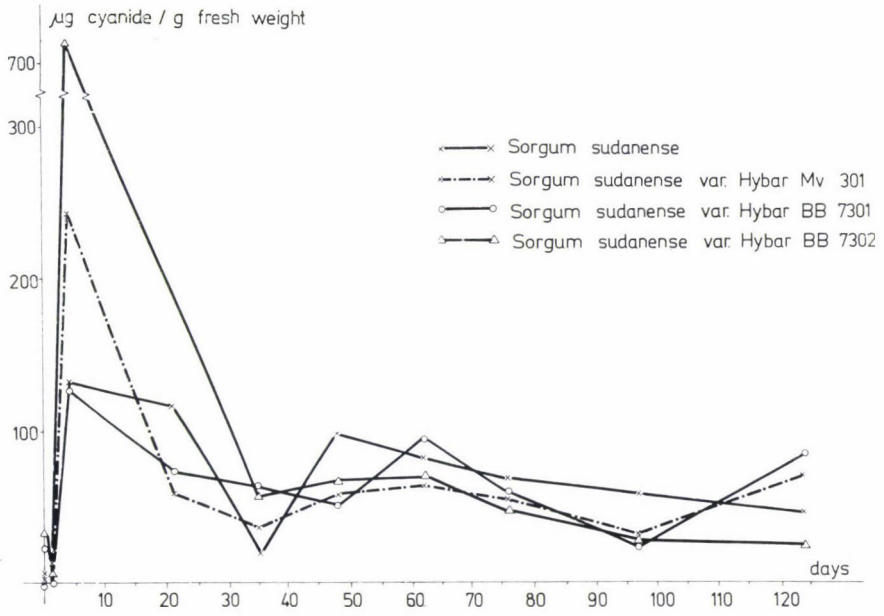

Fig. 1. Changes in the cyanogenic glycoside content during germination and vegetative development

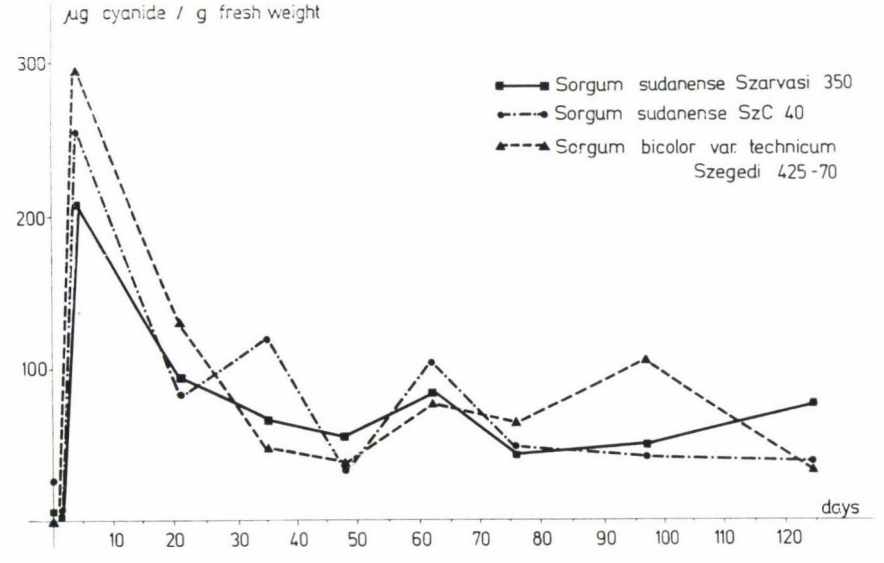

Fig. 2. Changes in the cyanogenic glycoside content during germination and vegetative development

Table 1

Changes in the cyanide contents of the examined plants of various age

		Cyanide (μg/g fresh weight) Age of plant (days)					
		0 (seed)	1	4	21	35	48
Sorghum sudanense	$\bar{x}$	3.22	22.36	131.79	117.48	19.95	96.22
	s	1.56	16.60	10.02	36.52	19.80	4.87
Hybar Mv 301	$\bar{x}$	2.15	15.05	242.22	58.45	36.76	58.42
	s	3.04	2.08	57.14	26.69	20.13	13.10
Hybar BB 7301	$\bar{x}$	21.92	0.00	127.54	71.79	62.34	50.11
	s	16.29	0.00	47.64	15.37	12.56	14.45
Hybar BB 7302	$\bar{x}$	33.10	7.09	714.75	—	59.33	67.43
	s	14.59	2.52	91.79	—	5.73	6.19
Szarvasi 350	$\bar{x}$	6.02	4.30	209.95	93.36	65.35	55.41
	s	8.51	3.36	39.06	6.81	7.25	21.19
SzC 40	$\bar{x}$	25.80	3.43	255.63	80.59	118.68	33.66
	s	23.20	1.87	52.21	20.10	19.56	17.62
Sorghum bicolor var. *technicum* Szegedi 425—70	$\bar{x}$	0.00	5.15	295.52	130.26	48.15	37.94
	s	0.00	2.33	67.01	26.49	6.65	12.90

of germination, that is, in the period of intensive longitudinal growth. The hydrogen cyanide values of the small seedlings were found to be very high, generally ranging between 130 and 300 μg/g fresh weight; one of the Hybar varieties (Hybar BB 7302) even attained a value of 714 μg. The data unanimously show that between the first and fourth days of growth a decisive change occurred in the HCN content, since we found an eight- to hundredfold increase of values.

On the next occasion samples for our experimental series were taken from 21 days old plants grown in culture pots. The HCN content measured in the leaves was lower; a few per cent decrease was found in *Sorghum sudanense*, and a very considerable (45—75 per cent) decrease in the other plants. On the 35th day the data showed a further decreasing tendency. The values obtained generally ranged between 36 and 65 μg/g fresh weight with the exception of *Sorghum sudanense* SzC 40 with 118.68 and *Sorghum sudanense* with 19.95 μg. Data related to unit fresh weight showed a further decrease, though the rate of decrease was somewhat slower. E.g. the CN^- content of *Sorghum sudanense* decreased gradually from 96 μg/g fresh weight on the 48th day to 46 μg/g by the 124th day. The figures clearly show that in the examined varieties of *Sorghum sudanense* a more or less similar tendency was observed. A few values deviating from the general trend of decrease or stagnation were also

($\bar{x}$: arithmetical mean; s: standard deviation)

content

				(μg/g dry weight)				
				Age of plant (days)				
62	76	97	124	48	72	76	97	124
80.47	67.40	59.33	46.43	628.31	475.57	398.33	363.69	232.0
25.08	3.95	13.72	11.00	31.80	148.22	23.34	84.10	55.0
64.00	54.56	25.05	68.79	379.14	371.84	354.09	148.04	286.1
14.93	18.74	19.35	16.56	85.01	86.74	121.52	114.35	68.8
92.66	58.82	24.29	81.48	325.21	579.12	394.68	137.96	449.7
27.41	13.65	12.13	11.79	95.78	171.31	91.59	68.89	65.0
69.01	46.82	22.90	22.78	498.98	436.14	279.98	122.97	84.2
29.63	11.14	16.00	16.00	50.80	187.26	66.61	85.92	59.2
82.98	42.57	30.49	75.24	443.28	429.85	272.82	192.69	268.6
27.71	10.76	17.58	16.51	169.52	143.53	68.97	111.10	58.9
103.84	43.21	39.80	38.05	288.88	592.92	302.03	243.97	158.28
30.78	11.87	8.53	10.06	119.81	175.75	82.97	52.28	41.8
77.18	62.02	102.01	33.10	291.75	484.69	465.77	621.24	149.61
40.64	20.76	16.70	18.56	99.20	255.21	155.90	101.70	83.89

Table 2

The data of dry matter content of the examined plants of various age (in per cent of fresh weight)
(x: arithmetical mean; s: standard deviation)

	Dry matter (in per cent of fresh weight)				
	Age of plant (days)				
	48	62	76	97	124
Sorghum sudanense	$\bar{x}$ 15.3	16.9	16.9	16.3	20.0
	s 0.5	0.5	1.9	0.8	1.0
Hybar Mv 301	$\bar{x}$ 15.4	17.2	15.4	16.9	24.0
	s 0.9	0.8	1.6	0.7	1.2
Hybar BB 7301	$\bar{x}$ 15.4	16.0	14.9	17.6	18.1
	s 0.1	1.7	0.3	0.3	0.7
Hybar BB 7302	$\bar{x}$ 13.5	15.8	16.7	18.6	27.0
	s 0.9	2.2	2.1	0.5	1.2
Szarvasi 350	$\bar{x}$ 12.5	19.3	15.3	15.8	28.0
	s 0.7	0.7	0.6	1.7	0.7
SzC 40	$\bar{x}$ 14.7	17.5	14.3	16.3	24.0
	s 0.3	0.4	0.2	0.8	1.6
Sorghum bicolor var. *technicum* Szegedi 425—70	$\bar{x}$ 11.3	15.9	13.3	16.4	22.1
	s 1.3	0.4	0.5	0.5	0.7

measured (e.g. 103.68 and 102.01 μg/g fresh weight in the 62 days old *Sorghum sudanense* SzC 40 and 97 days old *Sorghum bicolor* var. *technicum* Szegedi 425—70 plants, respectively).

The last samples taken on the 124th day were already at the state of flowering. The values obtained then were either the lowest of all in the function of time (Hybar BB 7302, *Sorghum bicolor* var. *technicum* Szegedi 425—70), or were near to the lowest values. In no case was any considerable increase in the hydrogen cyanide content pointed out.

The dry matter content of our plants gave values increasing between the 48th and 124th days in consequence of the organic matter production. The rate of increase generally was 5 to 15 dry weight percentage (Table 1). A considerable decrease of the data is generally seen, since e.g. the CN^- content of *Sorghum sudanense* was 60 per cent, that of Hybar BB 7302, 82 per cent lower. The change of the dry matter content represented but a small part of this remarkable change. It is interesting that the lowest cyanide values per unit dry weight were obtained in three cases for 97 days old and in four cases for 124 days old plants.

Discussion

In our investigations changes in the cyanogenic glycosides of *Sorghum sudanense* varieties in the course of development were measured as a part of a planned more extensive programme. The choice of plants was justified — among others — by the great agricultural importance of the *Sorghum* species and varieties of which account is given from a different aspect by a number of foreign and Hungarian data too (e.g. PECZNIK—RAÁTZ 1962, KÜKEDI 1968). The genetic and plant physiological investigations have already clarified some details of the metabolism of cyanogenic glycosides, and above all of the genetic aspects of cyanogenesis. In case of *Sorghum* species multigenic transmittance seems to be an established fact (BARNETT—CAVINESS 1968, HUGHES 1973). *Sorghum sudanense*, *Sorghum bicolor* as well as their varieties contain dhurrin (MAO *et al.* 1965). We know that this compound decomposes through a two-phase enzymatic reaction to glucose, hydrogen cyanide and p-hydroxybenzaldehyde (SEELY *et al.* 1966):

1. dhurrin $\xrightarrow{\beta\text{-glucosidase}}$ p-hydroxymandelonitrile + glucose
2. p-hydroxymandelonitrile $\xrightarrow{\text{oxynitrilase}}$ HCN + p-hydroxybenzaldehyde

Our studies are closely linked with earlier investigations into the cyanogenic glycoside content of Sudan grass. In fact, they are about two questions: 1. what is the amount of cyanogenic glycosides potentially present in the plant, and 2. what proportion — and that under what conditions — is hydrolysed and released in the toxic HCN?

It is known that the precursor of the biosynthesis of cyanogenic glycosides is an amino acid, e.g. tyrosine in the case of dhurrin, of which the compound may be formed through a short reactive pathway (CONN 1973). Practical experiences call attention to the dangers of excessive nitrogen fertilization too (PECZNIK—RAÁTZ 1962, GILLINGHAM *et al.* 1969).

Our data follow the changes of the HCN content in the *Sorghum* varieties and hybrids from the beginning of germination. It has been pointed out that the intensive changes of protein and nitrogen turnover, taking place during germination, induce a very high HCN value on the fourth day in all varieties. In a later phase of vegetative development the already photosynthetizing plants showed a gradually decreasing HCN production which from the 48th day on did not essentially change, not even at the stage of flowering. According to earlier data (WOLF—WASHKO 1967) in the three phases of growth of *Sorghum vulgare* var. SX-11 the value of HCN was always higher in the leaf blade and gradually decreased in the veins and stem. The authors explained the lower HCN content of older plants by the increasing proportion of plant parts with lower hydrogen cyanide contents. Our data contradict this theory by pointing out the stagnation or decrease of HCN content for the leaf blade only. We further found that the *Sorghum* species and varieties showed the maximum HCN content at an early stage of development.

Naturally, our data only refer to changes in the quantity of potentially given cyanogenic glycosides; the thorough knowledge of factors causing a quick hydrolytic decomposition is a different problem. The fairly large number of relevant data (e.g. TAPPER—REAY 1973) concern partly the enzymes of hydrolysis and the factors determining their activity, partly the role of various external factors (extreme weather conditions, frost, unbalanced water regime, various mechanical impacts, etc.). The aspects of fodder production, livestock breeding and toxicology also make it necessary to carry out many-sided and detailed studies on plants containing cyanogenic glycosides.

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MORPHOLOGICAL FEATURES OF INTERACTION AND CHELATE COMPLEXES OF MYOSIN CONTACT AMINO ACIDS WITH ATP

(EVIDENCE FOR THE EXISTENCE OF CYSTEINE—HISTIDINE AND CYSTEINE—ATP COMPLEXES)

By

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Experiments have been performed in order to confirm the fluorescence quenching of ATP interaction and chelate complexes (Fazekas *et al.* 1976), and the participation of contact amino acids (Lys, His) and methylated amino acids (Me-N^{τ}-His, TML) in the enzymatic activity of myosin. A considerable amount of evidence is given here, indicating that as the interaction and chelate crystals develop they have different morphological aspects and varying or strong anisotropy, showing that the crystals differ in their qualitative features, and also in shape and size. The results confirm not only the existence of ATP complexes, but also that of ATP-Cys, Cys-His and ATP-Cys-His interaction and chelate complexes, which must, presumably, be regarded as primary intermediates on the active site of myosin.

Introduction

ATP takes part in the enzymatic activity of myosin in the form of a Mg chelate (Bagshaw—Trentham 1974). Since a small amount of phosphohistidine was also found in alkaline hydrolysates (Fazekas—Székessy-Hermann 1974), we came to the conclusion that in the presence of ATP a number of high energy N phosphate bonds of histidine develop in the head part of myosin (Fazekas *et al.* 1976).

It was assumed that the contact amino acids (Lys, Cys) and methylated amino acids (N-Me-His,* TML**) of myosin take part in the phosphorylation of histidine, meanwhile forming interaction or chelate complexes. Tyihák *et al.* (1974) described the occurrence of a considerable number of methylated amino acids and summarised their biological functions.

The formation of myosin ATP intermediates causes a change in the ultraviolet spectrum of myosin (Bagshaw—Trentham 1974); but contact amino acids and methylated amino acids also alter the UV spectrum of ATP in vitro and induce the quenching of ATP fluorescence both in the presence and absence of $MgCl_2$, as described in a previous paper (Fazekas *et al.* 1976).

* 1-Me-His = Me-N^{π}-His, and 3-Me-His = Me-n^{τ}-His.
** N^{ε}-trimethyllysine.

These interaction and chelate complexes of ATP and His are very stable and develop various crystal structures. They provide in vitro evidence of the formation of ATP chelates with those amino acids which occur in the heavy chain of myosin, and show that this is also possible in vivo.

Material and methods

In order to demonstrate the crystal structure of the chelates, we used all the complexes which were prepared from stoichiometric ratios of ATP and contact amino acids of myosin for our fluorescence quenching examinations (FAZEKAS *et al.* 1976). In addition, the experiments were extended to include several new reaction mixtures, in order to confirm our previous results. Since the stability constant (log Ks) of complex formation depends on the number of ligands, and since this number is greatest when the metal–ligand ratio is 1 : 1, the stoichiometric ratio was chosen both for $MgCl_2$ and all the other ligands. The ligands were used either in their free form (His, Me-His, TML) or in the HCl form (Lys, Cys), while ATP was used as the monosodium salt, using exclusively 0.1 N NaOH in order to produce a pH of 7.0, so that the only secondary reaction product would be sodium chloride crystals. The reaction mixtures were diluted with an equal volume of acetone and the developing crystals were observed continuously, starting immediately after mixing. The residues of the reaction mixtures were stored at −15°C until the end of the experiment, i.e. for almost 2 months.

One or two drops of each mixture were crystallised on normal and grooved plates and the crystals were examined at room temperature with a Zeiss Ergaval microscope, using a polarisation device fitted with a $\lambda/4$ compensator plate in a diagonal position. All the photographs were taken using a Zeiss automatic camera with a Zeiss Planapochromat 16× objective and a Zeiss 3.2× ocular at standard camera length.

Results

The present paper offers evidence not only of fluorescence quenching but also of the formation of interaction and chelate complexes, as observed on the basis of dichroism. In the various reaction mixtures both weakly and strongly anisotropic crystals could be detected. The qualitative and morphological differences in the shape and size of the developing crystals were worthy of consideration.

The ATP fluorescence spectrum has a very narrow range in the ultraviolet, around 300 nm, and generates a close range maximum. Consequently it produces strongly anisotropic crystals with very pronounced dichroism (Fig. 1*a*). Microcrystal (b_1) and aggregate (b_2) forms of magnesium chloride are developed and these are also anisotropic, as are the needle-like crystals of histidine (*c*). Mg^{2+} ions have the effect of slightly reducing the ATP fluorescence emission; in a similar manner the anisotropy of the Mg–ATP chelate crystals is slightly different from that of ATP (*d*). Histidine, however, caused strong fluorescence quenching in the ATP–His derivate reaction mixture, and the needle-like crystals of histidine are no longer visible, since they are rearranged into a new complex. There is no noticeable change in the anisotropy of the ATP–Mg-His chelate complex (e_2), so the former ATP–His interaction complex is characterised by morphological uniformity, as are the ATP–Mg crystal com-

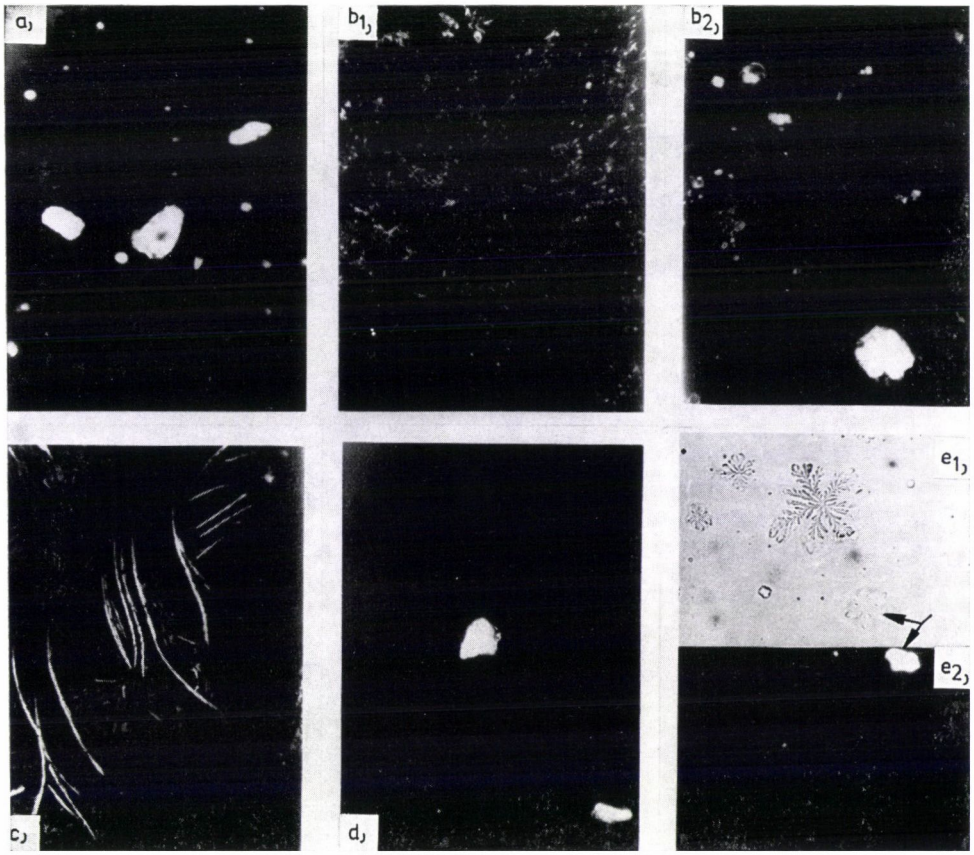


Fig. 1. Anisotropic crystals of ATP (*a*): microcrystal form (b_1) and later aggregated form (b_2) of $MgCl_2$; needle-like crystals of free histidine (*c*); crystals of ATP–His chelate (*d*); crystals of ATP–Mg-His triple chelate in native shots (e_1) and with a polarisation device (e_2). Arrows point to the same crystal

plexes (*d*), but the overlapping of the crystals and various external characteristics can also be seen in the native photographs (e_1).

The anisotropic crystals of 1-Me-His, the structure of which shows that they are composed of 4 sub-units, can be seen in Fig. 2*a*. It seems that the Mg-1-Me-His chelates disperse to monomer forms in the presence of $MgCl_2$, since they are very similar to the 1-Me-His subunits (*b*). The structure of the ATP–1-Me-His interaction complex is also very similar to that of the subunits (*c*), but in the 3-component ATP–Mg-1-Me-His chelate anisotropic crystals with a characteristically birefringent structure are formed (*d*).

Fig. 3 shows 3-Me-His and its derivates. The crystals of 3-Me-His are anisotropic and seem to be heterogeneous during their development, some of the crystals appearing to have a hexagonal surface when they first form (*a*).

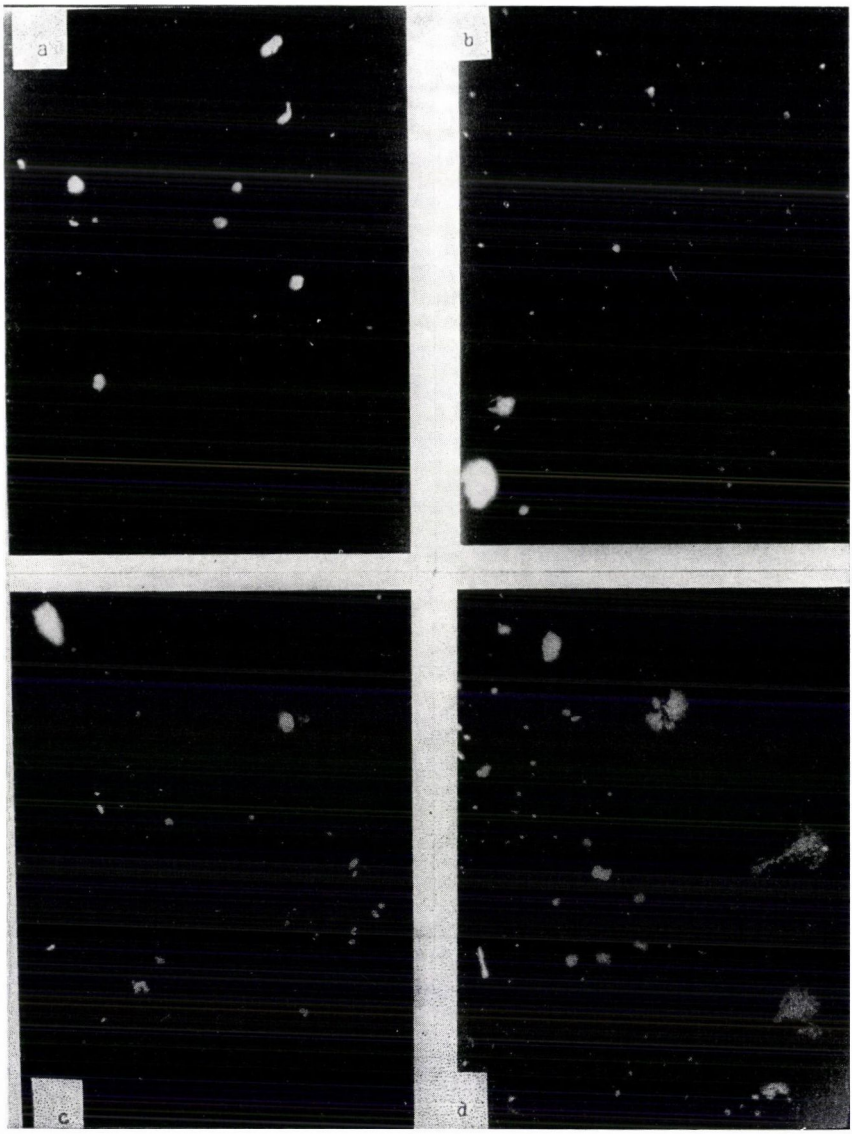


Fig. 2. Tetrameric crystals of 1-Me-His (*a*); microcrystals and rough crystals of 1-Me-His-Mg chelate (*b*); heterogeneous interaction complex of ATP–1-Me-His (*c*); developing dichroism in ATP–Mg-1-Me-His chelate crystals (*d*)

They are rearranged by Mg^{2+} ions into close-packed, but somewhat irregularly anisotropic chelate crystals (*b*), and by ATP into interaction crystals reminiscent of a strongly orientated Maltese cross, exhibiting very pronounced dichroism (*c*). The latter has a characteristic crystal form with Mg^{2+} ions in the triple ATP–Mg-3-Me-His chelate crystals (*d*). On the addition of histidine the

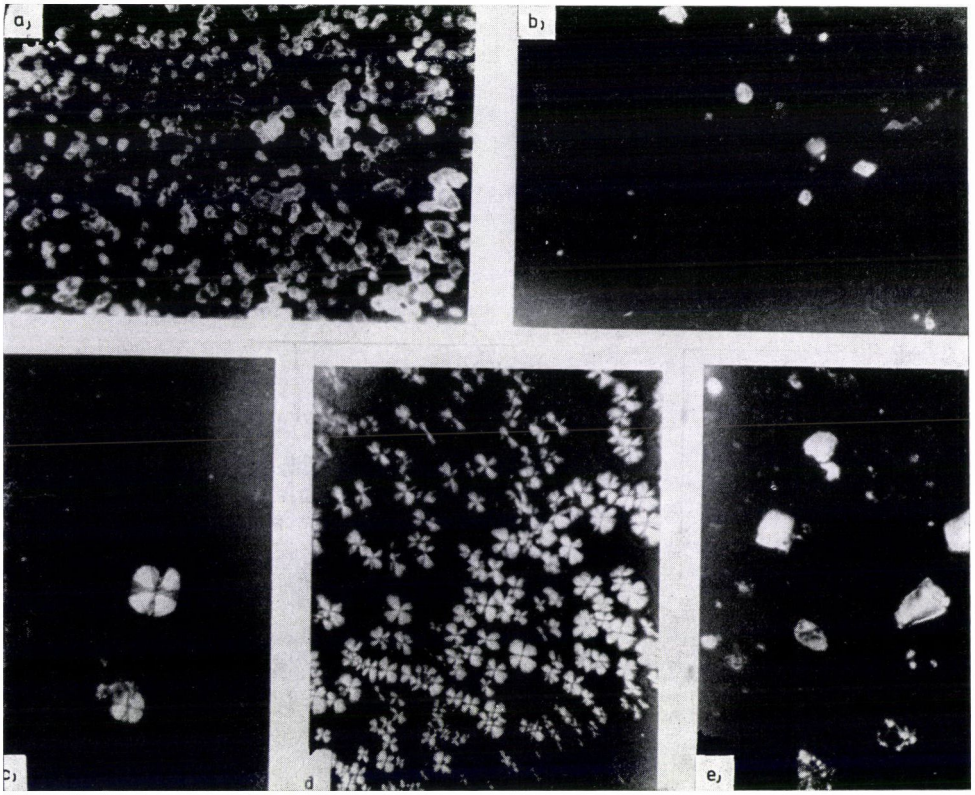


Fig. 3. Irregular, anisotropic crystals of 3-Me-His (*a*); compact anisotropic structure of 3-Me-His-Mg chelate (*b*); regular Maltese cross dichroism of ATP–3-Me-His interaction crystals (*c*); regular quadruple segments of Maltese cross of ATP–Mg-3-Me-His chelate (*d*); compact, irregular, anisotropic chelate complexes of ATP–Mg-3-Me-His-His (*e*)

Maltese cross structure becomes disarranged and the anisotropic prisms of the compact, quadruple ATP–Mg-3-Me-His-His chelate crystals develop (*e*).

His, 1-Me-His and 3-Me-His have different fluorescence spectra and crystal structures. On comparing Figs 1, 2 and 3 it may be observed that the histidines and Me-histidines also vary in their ability to form interaction and chelate complexes. These characteristics reach expression most efficiently in 3-Me-His, which is present in the head part of myosin.

Lysine and its derivates are shown in Fig. 4. The lysine crystals are arranged in a leaf-like structure (*a*). Lys exhibits very weak fluorescence emission, which was found to increase as the concentration of Lys rose. In our previous paper (FAZEKAS *et al.* 1976) we suggested that the slight increase in fluorescence might be the result of interaction between the lysine twin-ions. The ATP–Lys interaction mixture produces two kinds of crystals, one hexagonal with weak dichroism (b_1), the other of irregular structure with strong dichroism (b_2),

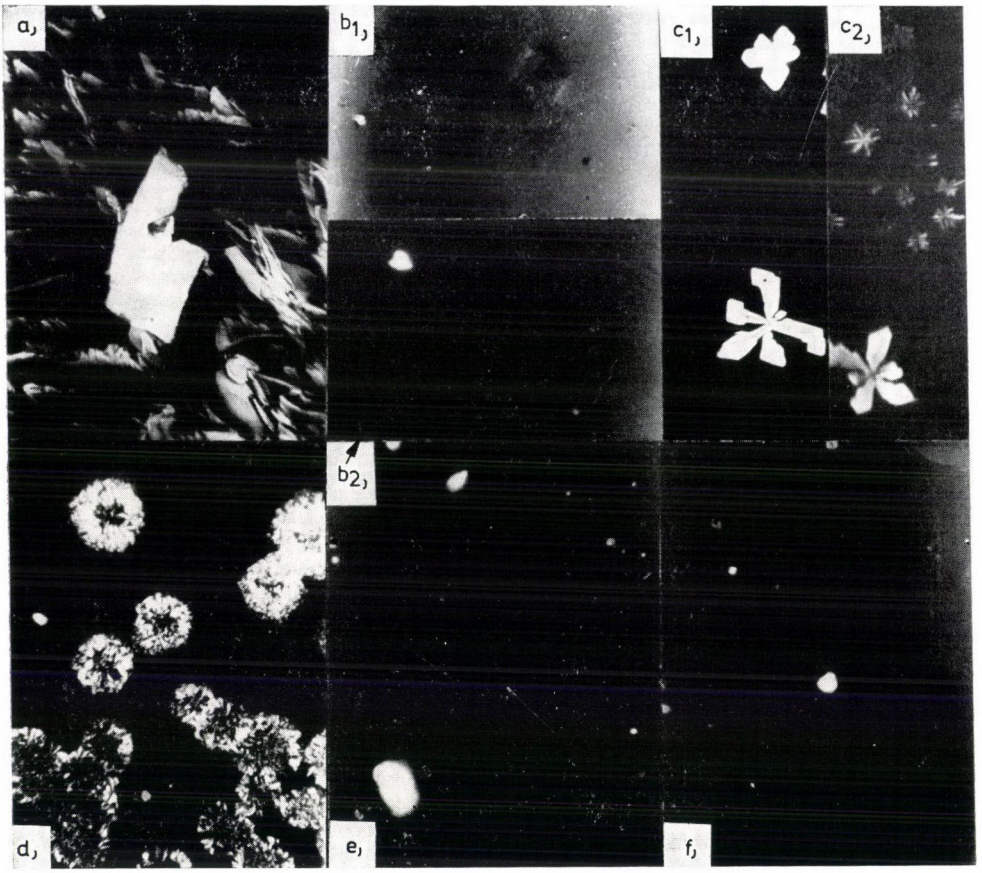


Fig. 4. Leaf-like structure of lysine hydrochloride (*a*); regular hexagonal crystals with weak anisotropy (b_1) and irregular crystals with strong anisotropy (b_2) of ATP–Lys interaction complexes; leaf-like, anisotropic structure (c_1) of Lys-Mg chelate, and the same developing into star-like crystals (c_2); bizarre rosette structure and dichroism of ATP–Mg-Lys chelate (*d*); irregular compact prisms of ATP–Mg-Lys-His chelate (*e*); irregular compact structure (without ATP) of the two amino acid Lys-Mg-His chelate (*f*)

while the Mg-Lys chelate crystals are strongly anisotropic and have bizarre, leaf-like shapes (c_1), which take up a star-like arrangement as they develop (c_2). Under the influence of ATP they are rearranged into even more bizarre, rosette-like, anisotropic ATP–Mg-Lys chelates (*d*), but histidine destroys the rosette structure and causes the compact, strongly anisotropic prisms of the ATP–Mg-Lys-Hisch elate to develop (*e*). Without ATP the anisotropic His-Mg-Lys chelate has a smaller structure composed of subunits (*f*).

TML has no crystal structure; only its hydrochlorides and salts formed with other organic acids (such as maleic and citric acids, etc.) have various characteristic crystal structures. We were unable to obtain a crystal structure

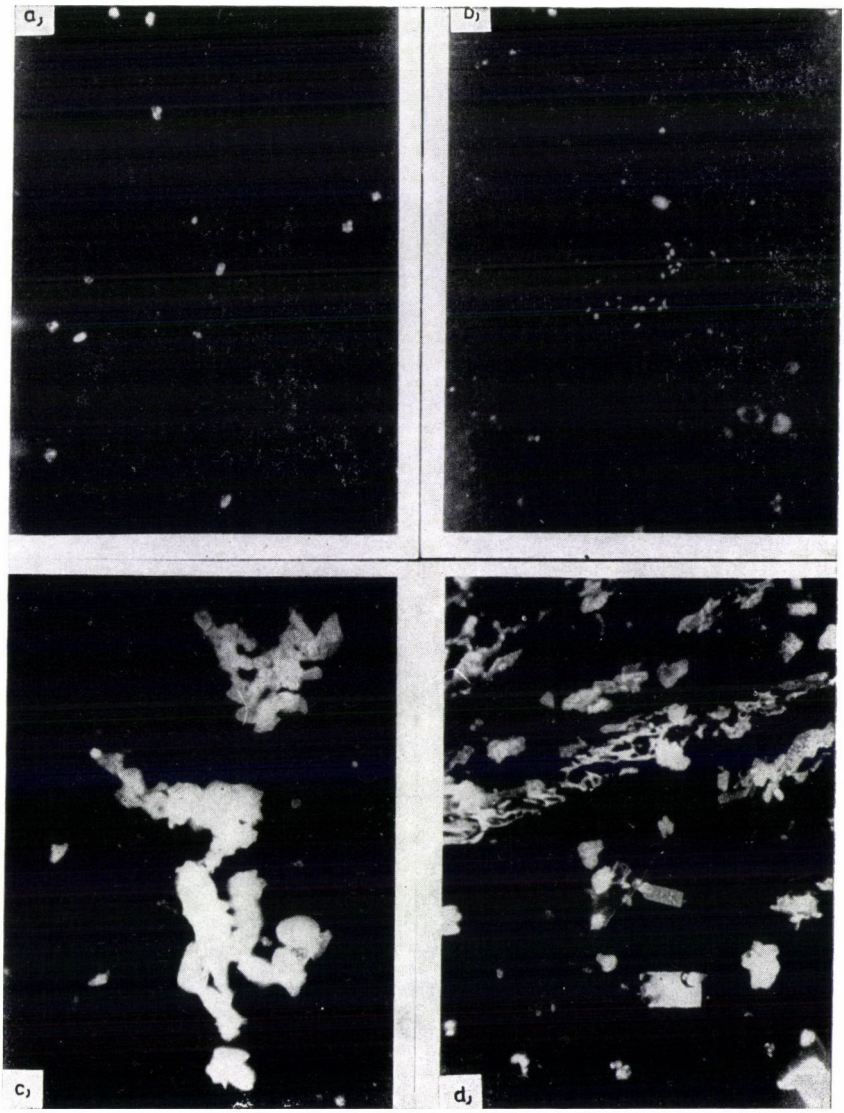


Fig. 5. Heterogeneity of TML–Mg-His crystals (*a*); dispersed and loose subunit interaction crystals of TML–ATP–His (*b*); irregular gigantic crystals of ATP–Mg–TML chelate (*c*); bizarre, irregular, anisotropic, quadrilateral sheet fragments of ATP–Mg–TML–His (*d*)

even in a free TML–acetone mixture, nor could microcrystals be observed under the microscope at standard magnification. It was also noteworthy that neither Mg^{2+} ion, His, nor a combination of Mg-His produced any change in the TML fluorescence spectrum. Thus it seems that TML does not form genuine interaction structures with Mg^{2+}, His or Mg-His. In Fig. 5 the TML–Mg-His chelate appears to have a crystal structure (*a*), but if we examine the crystals indi-

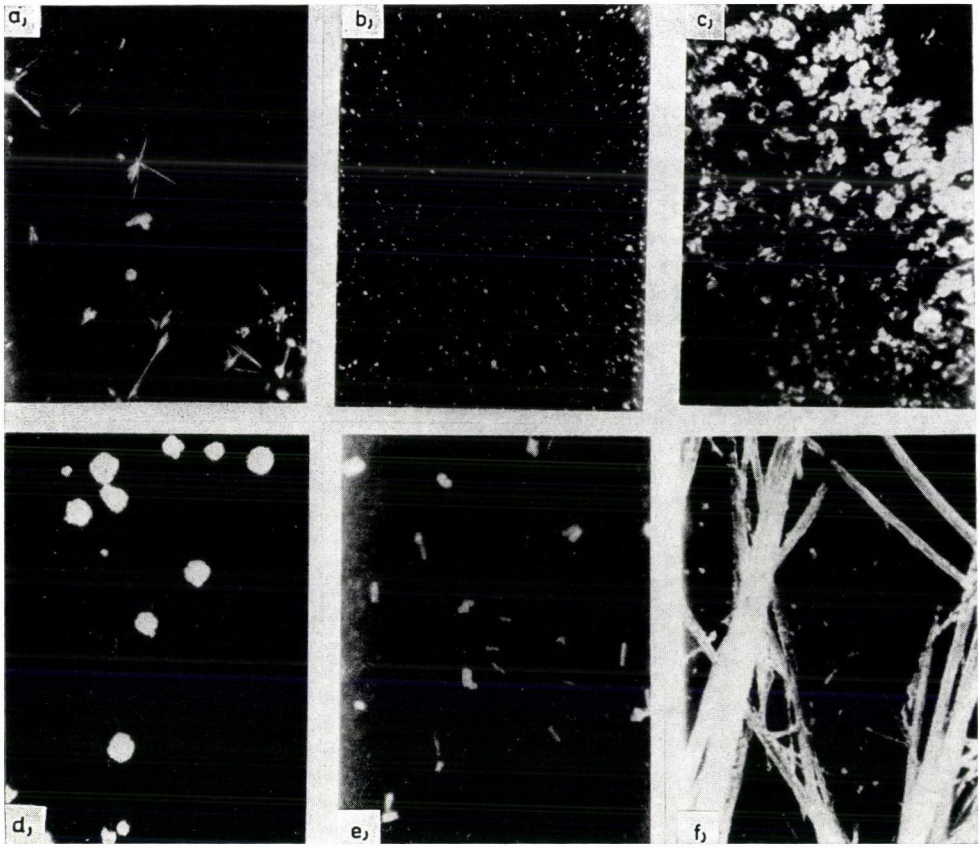


Fig. 6. Needle-like and variable crystal forms of cysteine hydrochloride (*a*); anisotropic micro-crystals of Cys-Mg chelate (*b*); variable forms of the rosette-like Cys-His interaction crystals (*c*) lacy-edged and segmented crystals of the Cys–ATP–His interaction complex (*d*); prism-like crystals of ATP–Mg-Cys chelate (*e*); thread-like, anisotropic chelate complexes of ATP–Mg-Cys-His (*f*)

vidually their heterogeneity becomes obvious, thus confirming the weakness of the affinity between the two amino acids and the Mg^{2+} ion. TML interacts very strongly with ATP, forming anisotropic tetrameric crystals, which are very similar to the TML–ATP–His interaction crystals, since they too are dispersed into monomers (*b*) and are monocrystalline. This composition shows the most impressive fluorescence quenching of ATP. The presence of Mg causes the formation of huge, compound granular TML–Mg–ATP chelate structures (*c*). On the addition of histidine compact, anisotropic, irregular quadrilateral sheet fragments are seen to develop in the TML–Mg–ATP–His chelate (*d*).

Cysteine and its derivates may be seen in Fig. 6. Cysteine hydrochloride forms needle-like anisotropic microcrystals (*a*), which are further arranged to

give various shapes. With Mg^{2+} ion Cys develops microcrystals of Cys-Mg chelate (*b*). This structure undergoes no further change, while the structure of the Cys-His interaction complex is extremely variable (*c*). It is formed of fine needles, from which a secondary rosette-like crystal structure develops, as may be seen at the edge of the figure. The crystals of the Cys–ATP–His interaction complex exhibit strong dichroism (*d*); if the crystals are examined separately they are seen to have lacy edges and to be made up of several segments. The Cys-Mg–ATP chelate is arranged in prism-like anisotropic crystals (*e*). When His is built into this structure the prisms undergo a considerable change, since the four components of the Cys-Mg–ATP–His complex are arranged as a very long, thread-like, anisotropic chelate complex (*f*). By carefully following the threads it may be seen that they are composed of even finer filaments.

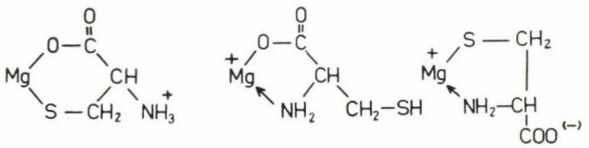
Discussion

According to the classification of SIDGWICH (1941) and BURGER (1973) the Mg^{2+} ion belongs to Group 3, which forms stable complexes with ligands containing not only oxygen donor atoms, but also nitrogen donor atoms. BAGSHAW—TRENTHAM (1974) came to the conclusion that the Mg^{2+} ion is associated with the nucleotide in each step of myosin enzymatic activity, forming a Mg–ATP chelate. We therefore gave priority to the study of the Mg^{2+} ion in the chelate formation of ATP and the contact amino acids of myosin.

WALAAS (1958) studied the stability constant (log Ks) of Mg and ATP complex formation. In the presence of Na ion it was found to have a value of 4.04 for Mg–ATP, 3.15 for Mg–ADP and nearly 4 for histidine.

The log Ks depends on the number of ligands and is characteristic of complexes formed from one, two, three or four ligand molecules. The degree of complex formation is greatest when the metal ion to ligand ratio in the mixture is 1 : 1, so both the Mg^{2+} ion and all the other chemicals were used in stoichiometric ratio.

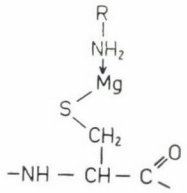
On the other hand we are aware that amino acids can form various chelate structures. For example, cysteine:



1 2 3

If the Cys is in a peptide chain only the third of these forms can take part in chelate formation, since the NH_2 donor group may also belong to other amino

acids. As was mentioned above, myosin contains two SH groups with completely different affinities and functions in enzymatic activity as far as the Mg–ATP substrate is concerned.



Consequently, all the series of crystals whose components might possibly take part in the development of enzymatic activity were examined one after the other, in order to gain information on the formation of interactions and chelates in the phosphorylation of myosin and in ATP hydrolysis. A comparison of the fluorescence quenching results obtained for interaction and chelate complexes shows a coincident correlation between the increase in fluorescence quenching and the tendency for the chelate forming ability to increase, even during interaction development.

1-Me-His and 3-Me-His exhibit differing crystallographic behaviour, while compared to histidine the electron-repulsing effect of the methyl group results in the development of an electron-dense N in the imidazol ring. The N^{π} electron-dense localisation in 3-Me-His is much stronger than that on the N^{τ} atom of the 1-Me-His imidazol ring. This was shown by the fluorescence quenching method and is now confirmed by crystallographic morphological analyses, since it is obvious that the strongly dichroic Maltese cross structure appears during the development of 3-Me-His interaction crystals, but not in a 1-Me-His–ATP mixture. In the presence of Mg^{2+} patchy dichroism is visible in the ATP–Mg-1-Me-His chelate, whereas the dichroism continues to increase in ATP–Mg-3-Me-His. This observation confirms that 3-Me-His has considerably more biological potential, giving it the advantage over 1-Me-His, and explains why the 3-Me form appears in myosin. Fluorescence analyses show considerable differences between TML–Mg-His and the chelates of TML and Mg–ATP, while the most orientated structure develops in the 4-component TML–Mg–ATP–His mixture, where a herring-bone-like structure sometimes develops from the quadrilateral fragments.

All the crystals seem to be different, so they may also be expected to have different biological functions.

While EDSALL (1965) reported that cysteine was not known to produce H-bonds, CSEKE (1974) has recently found N-S bonds among the Cys-149 and His-176 residues in D-glycerine aldehyde dehydrogenase. SOLAS–SUN (1975) report that interaction takes place between the neighbouring His-Cys in the active centre of transaldolase, and ADMAN *et al.* (1975) also observed

a number of NH . . . S bonds in ferredoxin. Our examinations confirmed the existence of Cys interaction and chelate complexes, demonstrating that they have different fluorescence intensities, while their crystals have different anisotropy and structure. It could be that for the SH_1 group in the peptide chain Lys is the electron donor for Cys, since the SH_1 group requires Mg ions in order to form bonds with ATP and ADP, but it is also possible that His is the electron donor in both Cys peptide chains. Furthermore, the function of the active site on the buried SH_2 with or without metal ion may depend on the phosphorylating or hydrolysing function of myosin. Our observations lead us to agree with BURKE *et al.* (1973) that the concentration (presence or absence) of Mg regulates the enzymatic activity of myosin on both the S_1 and the S_2 sites.

The above results indicate that chelates and interaction complexes of Cys participate in the development of enzymatic activity in myosin. Furthermore, both methods seem to be suitable for proving the existence of interaction and chelate complexes and are mutually complementary.

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PERFORMANCE OF SOME GENOTYPES OF LUCERNE UNDER WIDE AND NARROW SPACED-PLANTING

II. SELECTION FOR PARENT CLONES UNDER SPACE-PLANTED CONDITIONS

By

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Stem-cuttings of half-sib plants were selected under wide, medium, and narrow spacings from four genetically diverse types of lucerne and transplanted under two space-planted systems. The materials were randomized within the replications in the same way in the two spaced-planting systems. Genotypic and phenotypic variations expressed as genetic and phenotypic C. V. were greater under narrow than under wide spacing. The order of the genotypes investigated was clearly different under the two space-planted systems. Dry matter yield was the least resistant characteristic and plant height was the least susceptible characteristic under competition conditions. Selected genotypes of erect and semi-erect types from wide spacing were best when investigated under wide spacing, but were the worst when examined under narrow spacing. Selections of prostrate and semi-prostrate types from wide spacing gave higher yielding ability under wide than under narrow spaced-planting. The number of stems and the stem thickness were the most important factors affecting the performance of selected genotypes in the space-planted nursery when they are changed to drill conditions in commercial production.

Introduction

In any plant breeding program the evaluation of individual plants is of major importance. In perennial leguminous forage plants this problem is particularly difficult since the conditions in the space-planted breeding nursery differ so markedly from those for which strains are being produced. Individual forage plants cannot be evaluated exactly in a solid stand, and evaluating them as spaced plants is abnormal. Therefore, varieties built from information obtained under certain conditions, which are very different from those in which these varieties will be used in agriculture, will exhibit different kinds of performance.

When the variability of characters connected with yield conditions is sought, environmental variability should be reduced as much as possible, so that the variability of genetic differences between individuals may be better appreciated. It might be thought that with spaced plants it should be easier to discover the "genetic potential" of the individuals. However, when selected plants are grown under drill conditions, the competition with other plants may suppress the expression of different selected traits.

The first part of this study (RAMMAH—BŐJTÖS 1976) discussed the heritability of forage yield and related traits, and interrelationship between traits.

This part of the study was carried out in order to investigate the performance of the variability of different characters for some genotypes, which were selected from four growth habit types of lucerne under wide, medium, and narrow spaced-planting and examined as parent clones under wide and narrow spaced-planting systems.

A better understanding of competition among plants requires a greater knowledge of the response of an individual plant to its environment, especially its response to the environmental stress caused by its neighbours.

Competitive ability has already been studied as a genetic character (SAKAI 1955, DONALD 1963, SAYKUDO—YASUMURO 1968). A contradictory hypothesis was suggested by ROTILI—ZANNONE (1970). "Biological density" was referred to as a factor which influences the behaviour of the genotypes in a mixture.

SAKAI (1955) studied the competition effect on populations of barley and rice, and LICHTER (1972) studied it in sugar beet. They pointed out that the variation of plant characters due to competition must be taken into account, when these are affected by intergenotypic competition. The competitive ability may show a higher heritability value where the competitive advantage depends on a single morphological feature, e.g. plant height (DONALD 1963), while it has shown a very low heritability (OKA 1960) when measured by panicle number and plant height in a segregating rice population.

Density-genotype interaction was observed in ladino clover (SYAKUDO—YASUMURO 1968), in subterranean clover (STERN 1965), in red clover (BAEUMER 1964), and in lucerne (CHALBI 1967, ROTILI—ZANNONE 1971, ROTILI *et al.* 1973). SYAKUDO—YASUMURO (1968) concluded that the density-genotype interaction in ladino clover could be observed in stolon number, internode length and flower-head number, and that it was due to a change in the genetic variance. In terms of the range and variability of plant weight in subterranean clover, STERN (1965) found that the C. V. was nearly the same at all densities until the 90th day, after which it increased sharply for higher densities. In red clover sown at various plant densities and spacings, BAEUMER (1964) stated that the individual plant showed a very plastic response to spacing. Similar results were found in lucerne (CHALBI 1967) for quantitative characters such as the number of leaves in early stages, height, total number of stems, and the weight of dry matter yield, which showed important plastic modifications due to competition.

Many studies have been carried out to see how far the growth of sward plants can be related to the growth of the plant when widely spaced, and the results have been very variable. DOWNEY (1962) reported that a comparison for forage and seed yield of lucerne in drill and space-planted plots demonstrated that forage yield, but not seed yield, could be accurately evaluated using spaced planting. DAVIS *et al.* (1964) reported that testing lucerne as spaced-

plants can give a misleading impression of the same varieties in drills and broadcast plots as to their yield and tolerance to drought.

Various authors (ATWOOD—GARBER 1942, AHLGREN *et al.* 1945, and others) found that the estimated yields of single-plant selections bore no relationship to their relative yield in broadcast stands. AHLGREN *et al.* (1945) found that in Kentucky bluegrass eleven selections were significantly more productive than the standard variety when grown in mass seeding but that only two of these were classified as superior in the space-planted nursery.

COWETT—SPRAGUE (1963) found that the photoperiod affected the number of tillers, crown buds, and dry weight of alfalfa: as the stand density increased from 1 to 8 plants per square foot, the number of stems and dry weight per plant decreased. However, the yield per acre increased with increasing density.

RAMMAH—BŐJTÖS (1976) suggested that it would be better to evaluate the breeding material of lucerne under conditions relatively similar to those used in commercial production, in order to obtain meaningful estimates of genetic variance components for the material examined.

Materials and Methods

This study has been carried out in the breeding nursery of the Agricultural Research Institute at Kompolt. The materials used were stem-cutting of half-sib plants of four growth habit types of lucerne: erect habit (C—37), semi-erect (C—244), semi-prostrate (C—636) and prostrate habit (C—1474). On the basis of the total dry matter yield obtained from 3 cuttings, 12 half-sib plants from each type under study were selected as the best 10% from a segregating population space-planted in three different ways. Four of the 12 selections were selected from the wide space-planted system (30 cm between and within rows), 4 plants from the medium space-planted system (20 cm between and within rows), and the other 4 plants from the narrow space-planted system (10 cm between and within rows).

A hundred stem-cuttings were taken from each selected plant and mother clone, too. Thirty cuttings uniform in their root vigour were transplanted to the experimental field in May 1973. A total of 8 randomized block experiments with three replications were established; each replication consisted of a 5-plant row of the mother clone and 11 or 12 selections. This gave a total of 13 experimental rows within the replication for the semi-erect and semi-prostrate types, and 12 experimental rows for the erect and prostrate types, as one selection had died. Selections from each type were compared in the wide space-planted system (30 cm between and within rows) and the narrow space-planted system (10 cm between and within rows). Randomization of the materials within the replications was the same for each of the space-planted systems, with a guard row on each side of the experiment.

The plants were cut three times up to September 1973. The unit of observation was the 5-plant row; stand counts per row were made after each cutting and the yield was expressed as grams of green yield, dry matter yield, dry stem weight, and dry leaf weight. Samples of 100 grams or less were used for leaf/stem separation and for dry weight calculations. The leaf/stem separation was made by separating the leaflets and leaf-stems were included with the main stem as part of the stem weight. The stems and leaves were dried until the stable weight and the total weight of the two components gave the weight of dry matter yield

Other characteristics measured were plant height and the number of stems. The plant height, in centimetres, was obtained by measuring the longest stem from the soil surface to the highest tip for single plants within the row, but an average of the height of 5 plants was used in computing. The number of stems arising from the basal nodes was calculated after cutting and was expressed as the number of stems per plant.

Data from the two space-planted experiments were subjected to analysis of variance. The means of half-sib clones from the two space-planted systems were ranked, and the L.S.D. between the means was calculated.

The extent of intraprogeny variability for the various characters studied was compared within the half-sib clones of the different types of lucerne under investigation using the phenotypic coefficients of variation. The genetic coefficients of variation, the genetic C.V. and the square root of the genetic variance (σ^2_g), expressed as a percentage of the mean (BURTON—DE VANE 1953), were calculated and used as an index of relative genetic variability for various traits.

In order to test the half-sib groups of the four growth habit types of lucerne included in this study with respect to their relative variability for the sum totality of characters investigated, a system was used based on the transformation of ranked data to scores given in tables by FISHER—YATES (1953). This system consists of arranging the coefficients of variation of the four types for each character in an ascending order. Scores from the tables are then assigned to the numerical rank of the types for each character, thereby giving all characters equal weight. These scores can be subjected to regular analysis variance to detect differences among the four types in total variability.

To evaluate competition between neighbouring genotypes (rows) under the two space-planted systems, the correlations between neighbouring rows were calculated for different characters (LICHTER 1972). The average of three replications for the selections, in three selected groups each representing selections under different space-planted conditions, were calculated and compared with the general mean of the selected population in order to evaluate the performance of selections from a certain space-area under two levels of competitive conditions in the space-planted nursery.

Results

1. *Intraprogeny variability (variability within half-sib clones).* The intraprogeny variability of the four types of lucerne was studied by reference to the coefficients of variation.

a) *Degree of character variability.* An arithmetic mean phenotypic coefficient of variation was obtained for each character over all the progeny; these mean values are listed in the last column of Table 1. A comparison of the mean

Table 1

Phenotypic coefficient of variation (%) for various characters of the total of three cuts of selected parental clones from four growth types of lucerne, tested under two space-planted conditions

Character	Spacing	Phenotypic C.V., %				General average
		Erect	Semi-erect	Semi-prostrate	Prostrate	
Plant height	W	10.3	5.7	5.4	6.9	7.1
	N	11.0	6.2	9.7	10.1	9.2
Green yield	W	13.3	23.2	23.1	16.6	19.0
	N	29.2	29.1	36.2	30.6	31.3
Number of stems	W	36.6	21.1	16.3	17.6	22.9
	N	18.9	13.0	22.1	22.5	19.1
Dry matter yield	W	29.4	24.4	23.7	17.8	23.8
	N	29.2	29.8	35.6	30.5	31.3
Dry stem weight	W	31.8	26.5	26.0	19.3	25.9
	N	30.8	32.9	35.2	34.7	33.4
Dry leaf weight	W	28.1	23.1	21.5	17.2	22.5
	N	28.3	27.6	37.0	26.1	29.8

W = Wide spacing; N = Narrow spacing

phenotypic coefficients of variation revealed that the characters studied differed in their degree of variability. Plant height was the least variable character studied under wide (7.1%) and narrow (9.2%) spacings. Other characters measured showed extreme variability, progressing through total green yield (19.0%), dry leaf weight (22.5%), number of stems (22.9%), dry matter yield (23.8%) and dry stem weight (25.9%) for phenotypic C.V. under wide spacing. The same characters measured under narrow spacing showed extreme variability progressing through plant height (9.2%), number of stems (19.1%), dry leaf weight (29.8%), green yield (31.3%), dry matter yield (31.3%) and dry stem weight (33.4%).

The genetic coefficients of variation, as an index of relative genetic variability, were computed and are listed in Table 2 and the arithmetic mean

Table 2

Genotypic coefficient of variation (%) for various characters of the total of three cuts of selected parental clones from growth types of lucerne, tested under two space-planted conditions

Character	Spacing	Genotypic C.V., %				General average
		Erect	Semi-erect	Semi-prostrate	Prostrate	
Plant height	W	8.9	9.8	10.3	11.7	10.2
	N	10.3	13.7	10.4	11.1	11.4
Green yield	W	13.4	13.5	22.2	24.1	18.3
	N	34.6	33.5	29.6	33.4	32.8
Number of stems	W	13.4	35.2	24.8	26.2	24.9
	N	12.2	24.0	16.6	34.0	21.7
Dry matter yield	W	15.0	13.0	21.9	23.3	18.3
	N	31.7	33.5	31.5	34.9	32.9
Dry stem weight	W	11.8	10.9	25.5	26.3	18.6
	N	35.1	36.0	37.0	36.3	36.1
Dry leaf weight	W	18.7	16.8	19.0	22.3	19.2
	N	32.1	30.1	25.1	35.1	30.6

was obtained for each character over all the progeny and is listed in the last column of this Table. The data presented in Table 2 show that genetic variability is mostly expressed under narrow spacing. The number of stems (24.9%), dry leaf weight (19.2%), dry stem weight (18.6%), dry matter yield (18.3%), green yield (18.3%) and plant height (10.2%) showed decreasing genetic variability, in this order, under wide spacing. Under narrow spacing, the dry stem weight (36.1%), dry matter yield (32.9%), green yield (32.8%), dry leaf weight (30.6%), number of stems (21.7%) and plant height (11.4%) decreased in the above order.

b) *Relative variability*. The results of the analysis of variance for the four types are presented in Table 3. The data listed in Table 3 reveal signifi-

Table 3

Analysis of variance for scores of clonal material from four types of lucerne tested under wide and narrow spaced-plantings

Spacing	Source of variation	d. f.	m. s.
Wide	types	3	11.2057*
	residual	20	2.6051
	total	23	13.8108
Narrow	types	3	7.6948
	residual	20	6.1160
	total	23	13.8108

* significant at the 5% level.

cant differences at the 5% level between the four types in total variability only under wide spaced-planting.

2. *Interprogeny variability (variability between half-sib clones).* The results of the analysis of variance for differences between half-sib clones within each type of growth habit under the two space-planted conditions are presented in Table 4, and the means of half-sib clones for the various characters were calculated and are listed in Table 5. The results in Tables 4 and 5 show that half-sib clones of the erect type did not differ significantly under wide spacing

Table 4

Mean squares from analysis of variance for various characters of half-sib parental clones from four types of lucerne grown under two space-planted conditions

Character	Spacing	Genotypes, mean of squares			
		Erect	Semi-erect	Semi-prostrate	Prostrate
Plant height	W	848.95*	725.23*	817.39**	791.20**
	N	657.43**	961.06**	628.07**	506.85**
Green yield	W	2142.09	1599.99	2826.49**	2720.98**
	N	332.51**	457.37**	460.17*	440.31**
Number of stems	W	158.37	790.46**	630.16**	1086.91**
	N	29.69	98.10**	81.36*	445.01**
Dry matter yield	W	116.23	98.82	159.16**	145.15**
	N	16.62**	25.69**	28.77**	23.45**
Dry stem weight	W	34.64	26.65	65.49**	54.60**
	N	5.84**	8.99**	10.99**	7.45**
Dry leaf weight	W	25.87	23.64*	24.05**	27.04**
	N	3.51**	4.30**	4.49*	4.84**

**, * significant at the 1 and 5 per cent levels, respectively.

for any of the characters studied except the plant height. Significant differences at the 5% level were obtained between half-sib clones of the semi-erect type for plant height and leaf weight, and at the 1% level for the number of stems. In narrow spacing, highly significant differences at the 1% level were computed for all traits of the erect and semi-erect types, except for the number of stems in the erect type. The analysis of variance for half-sib clones of the prostrate and semi-prostrate types showed significant differences under wide and narrow spacing for all the traits studied. Also, the mean values were ranked in order in histograms (Figs 1—4) using scores given in Table XX by FISHER—YATES (1953). A close examination of the means in the four figures reveals that the order of means under wide spacing was different from that under narrow spacing. In most cases, genotypes with low values under wide spacing remained low under narrow spacing. Other genotypes sharply differed under the two systems, while some genotypes were in the same order under the two planting systems.

3. *Effect of neighbouring genotypes upon each other.* Correlation coefficients for the same character between two neighbouring genotypes within the replications were calculated under the two space-planted systems and are listed in Table 6. More positive correlations were obtained for all traits of the erect and semi-erect types under wider spacing in the three replications. Under narrow spacing the substitution of the neighbouring genotype by another one was more effective in changing the direction of correlation between neighbouring genotypes than it was in wide spacing for all characters except the plant height of erect and semi-erect types. For prostrate and semi-prostrate types negative correlations were obtained under wide spacing and more positive values were calculated under narrow spacing.

4. *Evaluation of selected parent clones under three spaced-planting systems.* A general mean for the selected population for each of the six characters studied was computed and used as a measure to compare the efficiency of selecting parent clones in the nursery under three space-planted areas. Deviation of the means of selected groups from the general mean are presented in Table 7.

The mean of group I from erect habit type gave positive deviations for all characters when examined under wide spacing; the deviations ranged from +0.7% for plant height to +20.9% for the number of stems. All traits, except the number of stems, were lower than the general mean under narrow spacing. Most characters of groups II and III were diagonally opposed to those of group I. This was demonstrated by increases under narrow and decreases under wide space-planting systems. Plant height for group III gave an almost equal amount of slight stimulation under wide (+3.0%) and narrow (+3.8%) spaced-planting.

In semi-erect habit, negative deviations were calculated from group I for plant height and green yield under the two planting systems, but the num-

Table 5

Means for various characters of clonal material

Genotype	Erect type											
	Characters											
	1		2		3		4		5		6	
	N	W	N	W	N	W	N	W	N	W	N	W
1	119	155	26	110	22.3	44.8	6.4	26.2	3.3	15.5	3.1	10.7
2	117	169	23	143	18.4	44.4	5.7	33.9	3.1	19.8	2.6	14.1
3	118	152	27	156	23.2	52.7	6.6	37.3	3.4	20.5	3.2	16.8
4	113	138	19	102	19.1	35.7	4.7	22.8	2.6	13.6	2.1	9.2
5	130	168	33	139	20.2	33.3	7.7	31.7	4.1	17.5	3.6	14.2
6	137	178	36	145	22.2	40.2	8.6	32.6	4.9	18.7	3.7	13.9
7	112	123	24	103	16.8	30.7	5.7	25.2	3.2	13.5	2.5	11.7
8	96	135	11	70	15.7	29.0	2.7	16.2	1.4	9.6	1.3	6.6
9	127	163	24	101	15.7	27.8	5.6	23.8	2.8	13.3	2.8	10.5
10	128	140	44	127	22.6	38.0	10.3	29.7	5.2	15.7	5.1	14.0
11	—	—	—	—	—	—	—	—	—	—	—	—
12	115	156	28	87	13.9	27.9	3.7	19.5	2.0	11.3	1.7	8.2
13	154	171	46	138	20.9	41.0	10.6	30.2	6.3	17.8	4.3	12.4
L.S.D.	23	—	14	—	—	—	3.2	—	1.9	—	1.4	—
	Semi-prostrate type											
1	118	153	46	140	29.6	27.7	10.9	32.7	5.6	17.8	5.3	14.9
2	93	121	14	69	18.1	36.3	3.1	15.9	1.5	8.4	1.6	7.5
3	112	138	26	113	21.6	55.4	5.9	26.4	3.2	13.8	2.7	12.6
4	130	172	37	167	23.3	69.8	9.2	40.0	5.4	23.6	3.8	16.4
5	113	143	30	111	24.7	60.1	7.4	25.7	3.7	12.7	3.7	13.0
6	129	156	34	115	24.3	42.3	8.6	28.6	4.4	15.8	4.2	12.8
7	127	176	29	126	26.1	52.2	7.3	30.1	4.1	17.6	3.2	12.5
8	144	177	50	176	31.6	73.8	12.4	42.6	7.3	25.7	5.1	16.9
9	123	145	24	84	13.0	26.2	5.7	20.1	3.0	11.1	2.7	9.0
10	108	144	23	129	21.4	65.3	5.1	29.0	2.5	14.7	2.6	14.3
11	131	169	36	124	28.4	69.0	8.7	28.9	5.1	16.8	3.6	12.1
12	146	152	60	90	28.7	39.5	14.5	21.6	8.6	11.2	5.9	9.4
13	114	142	38	96	31.2	57.1	8.9	23.8	4.8	13.6	4.1	10.2
L.S.D.	20	14	31	46	9.3	14.9	4.9	11.2	2.7	6.9	2.3	4.5

Characters: 1 — Plant height; 2 — Green yield; 3 — Number of stems;

genotypes tested in wide and narrow spacings

Semi-erect type											
Characters											
1		2		3		4		5		6	
N	W	N	W	N	W	N	W	N	W	N	W
113	144	23	100	15.5	30.5	5.6	22.7	3.1	12.1	2.5	10.6
99	117	24	140	33.6	81.3	5.7	35.2	2.7	17.5	3.0	17.7
115	132	40	128	33.4	71.3	9.7	39.2	5.0	20.4	4.7	18.8
130	153	32	101	21.9	36.4	7.9	25.6	4.6	14.7	3.3	10.9
105	146	19	92	18.7	30.7	4.3	22.6	2.1	12.6	2.2	10.0
125	143	25	119	22.0	44.2	6.9	28.0	3.8	15.0	3.1	13.0
145	167	50	139	21.6	32.4	11.8	32.0	6.7	18.2	5.1	13.8
138	157	41	116	27.9	48.5	9.8	28.0	5.4	15.0	4.4	13.0
139	142	39	157	24.3	47.6	8.9	36.6	5.1	21.4	3.8	15.2
116	155	20	132	17.8	40.4	4.3	31.6	2.2	17.6	2.1	14.0
119	154	27	115	19.0	32.3	5.9	25.2	3.2	13.4	2.7	11.8
165	168	60	104	21.8	27.5	13.9	23.8	8.0	13.0	5.9	10.8
123	151	25	96	18.1	41.2	5.9	23.9	3.3	13.5	2.6	10.4
13	15	16	—	5.0	15.4	3.9	—	2.4	—	1.6	—
Prostrate type											
118	149	27	80	26.3	48.0	6.7	19.5	3.7	11.2	3.0	8.3
112	141	41	145	33.8	67.8	9.3	34.1	4.8	18.6	4.5	15.5
90	132	20	138	26.4	73.1	4.6	32.6	2.4	17.4	2.2	15.2
107	145	39	154	46.3	92.3	8.6	36.7	4.9	20.8	3.7	15.9
82	105	19	83	34.2	66.8	3.7	19.5	1.7	9.6	2.0	9.9
106	130	35	135	42.3	91.4	8.9	32.7	4.5	17.5	4.4	15.4
116	148	34	110	27.0	59.2	7.0	24.7	4.4	15.7	2.6	9.0
117	151	43	156	32.5	72.7	9.4	34.7	5.2	20.5	4.2	14.2
83	122	11	76	15.8	45.9	2.3	18.7	1.1	9.5	1.2	9.2
109	133	36	119	43.6	71.4	8.1	28.6	4.3	16.4	3.8	12.2
91	108	23	81	16.0	31.4	4.8	18.3	2.3	9.2	2.5	9.1
—	—	—	—	—	—	—	—	—	—	—	—
102	113	53	115	56.4	9.1	11.9	26.2	6.3	12.9	5.6	13.3
18	15	17	33	12.7	20.2	3.7	8.2	2.2	4.9	1.4	3.6

4 — Dry matter yield; 5 — Dry stem weight; 6 — Dry leaf weight

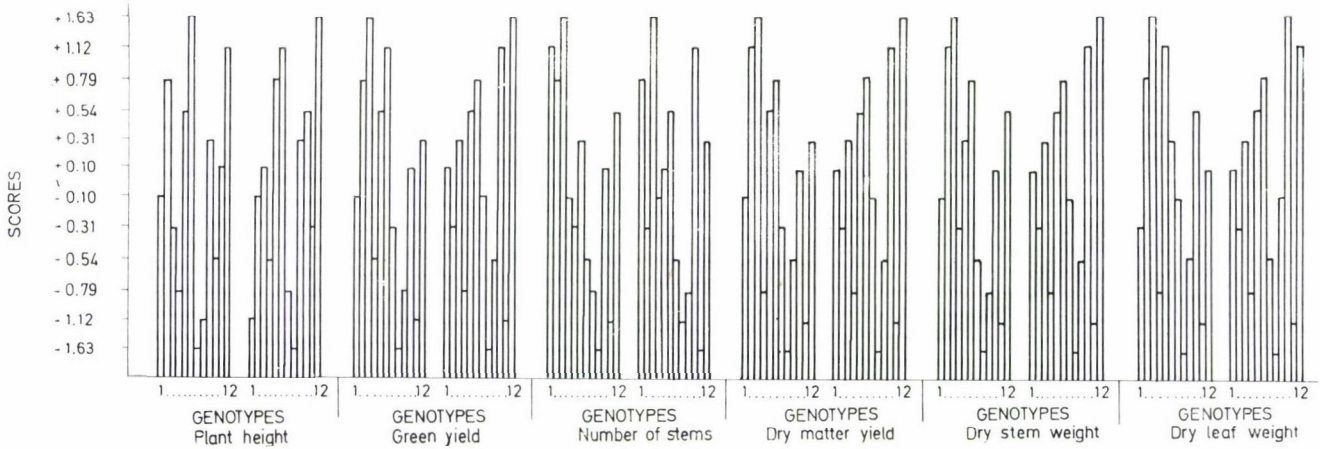

Fig. 1. Ranks for 12 genotypes of erect type in wide (left) and narrow (right) spacings. Traits are presented as total of three cuts per plant

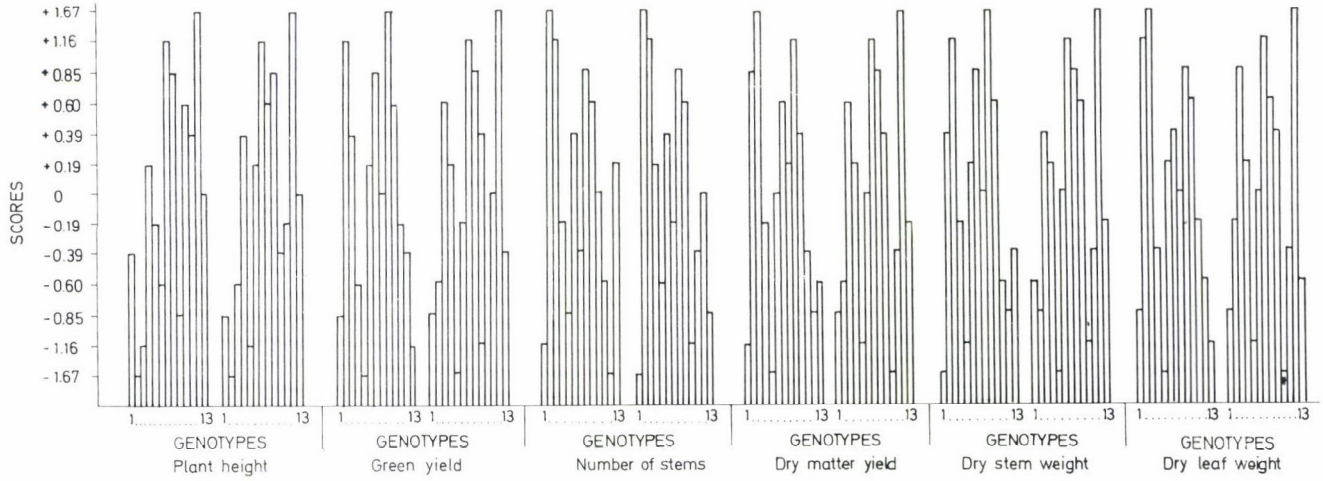

Fig. 2. Ranks for 13 genotypes of semi-erect type in wide (left) and narrow (right) spacings. Traits are presented as total of three cuts per plant

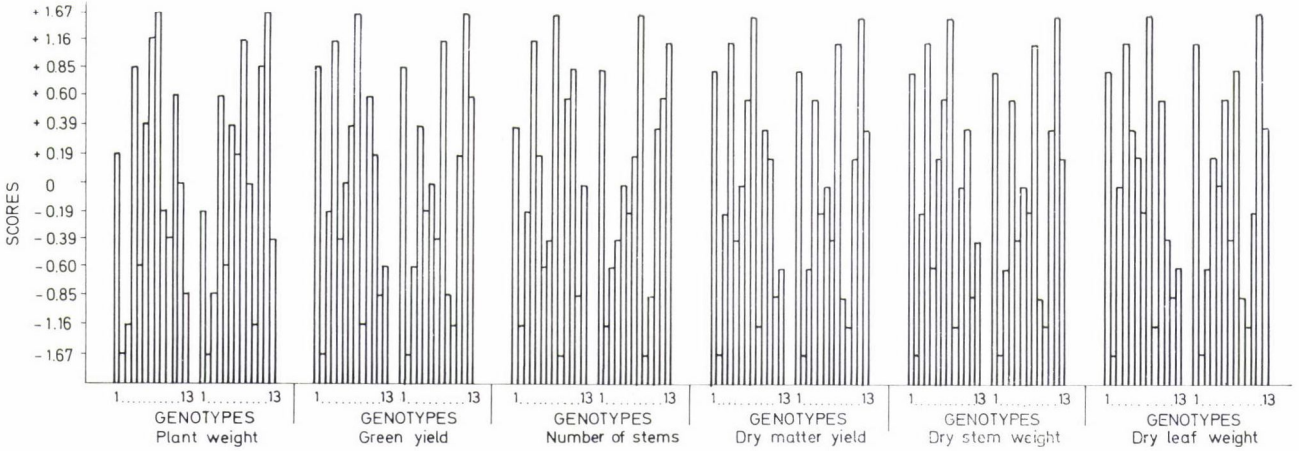

Fig. 3. Ranks for 13 genotypes of semi-prostrate type in wide (left) and narrow (right) spacings. Traits are presented as total of three cuts per plant

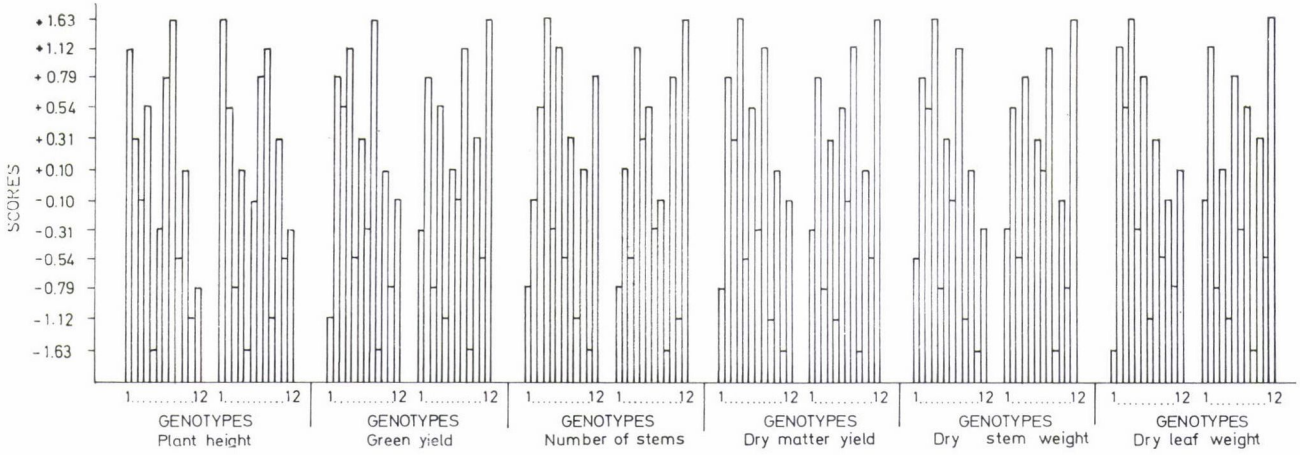

Fig. 4. Ranks for 12 genotypes of prostrate type in wide (left) and narrow (right) spacings. Traits are presented as total of three cuts per plant

Table 6

Correlation values between the same trait of neighbouring genotypes in three replications under wide and narrow spaced-plantings

Traits	Spacing	Erect			Semi-erect		
		Rep. 1	Rep. 2	Rep. 3	Rep. 1	Rep. 2	Rep. 3
Plant height	W	+.11	+.28	+.86	+.32	+.26	−.62
	N	+.10	+.02	+.34	+.17	−.09	+.02
Green yield	W	+.63	+.68	−.28	−.58	−.44	+.54
	N	−.29	−.24	+.29	−.09	+.35	−.40
Number of stems	W	+.59	+.71	+.68	−.37	+.20	−.04
	N	−.24	−.41	−.55	+.15	−.01	−.27
Dry matter yield	W	+.63	+.68	−.21	−.59	−.23	+.27
	N	−.31	−.21	+.07	−.10	+.12	−.33
Dry stem weight	W	+.67	+.20	−.18	−.41	−.45	+.14
	N	−.24	−.05	−.22	−.12	+.06	−.29
Dry leaf weight	W	+.52	+.69	−.23	−.68	−.03	−.21
	N	−.36	−.42	+.15	−.06	+.03	−.33

Traits	Spacing	Semi-prostrate			Prostrate		
		Rep. 1	Rep. 2	Rep. 3	Rep. 1	Rep. 2	Rep. 3
Plant height	W	−.25	−.36	−.31	−.29	−.15	+.66
	N	−.22	−.09	+.67	+.32	−.39	+.09
Green yield	W	+.10	−.78	+.14	−.61	+.20	+.19
	N	−.09	−.53	+.58	−.42	−.58	−.40
Number of stems	W	+.23	−.91	+.62	−.66	+.79	+.74
	N	−.20	−.51	+.92	−.17	+.35	+.07
Dry matter yield	W	+.23	−.39	+.06	−.77	+.28	+.20
	N	−.10	−.60	+.62	−.43	−.68	−.53
Dry stem weight	W	+.38	−.65	+.08	−.74	−.07	−.14
	N	+.06	−.50	+.62	−.39	−.42	−.54
Dry leaf weight	W	+.04	−.85	+.20	−.58	+.63	+.76
	N	−.27	−.74	+.60	−.44	−.70	−.52

ber of stems exceeded the general mean for the selected population by 26.2% and 12.9% respectively under narrow spacing. Groups II and III, tested under wider spaced-planting, showed some stimulation for plant height, but there was a depression in the number of stems under the spaced-plantings compared with the general mean for the selected population.

For semi-prostrate habit, under wide spacing only, group I exceeded the general mean for all characters except plant height. Group II was superior for all characters under the two spaced-plantings with greater superiority under wide spacing, except for plant height, where the superiority was greater under narrow than under wide spacing. Group III slightly exceeded the general mean under narrow spacing for all characters, except for the number of stems,

Table 7

Deviations (%) for means of selected groups from the general mean of the selected population (excluding mother parent), examined under wide, medium and narrow spaced-plantings

Character	Spacing	Erect			Semi-erect		
		group I	group II	group III	group I	group II	group III
Plant height	W	+0.7	−0.8	+3.0	−4.4	+7.5	+9.0
	N	−3.2	+0.3	+3.8	−9.0	+2.0	+7.0
Green yield	W	+9.6	−2.1	−9.7	−2.1	−3.2	+5.4
	N	−7.4	+1.5	+8.2	−10.2	+1.5	+9.0
Number of stems	W	+20.9	−9.2	−14.9	+26.2	−10.5	−15.1
	N	+8.3	−2.0	−8.9	+12.9	−2.5	−10.3
Dry matter yield	W	+10.4	−2.8	−10.1	+4.1	−6.9	−13.1
	N	−4.8	+1.6	+6.6	−8.6	+4.4	+4.5
Dry stem weight	W	+12.8	−3.7	−12.1	+0.4	−2.4	+2.0
	N	−4.8	+3.3	+1.8	−11.3	+4.8	+6.9
Dry leaf weight	W	+7.4	−1.6	−7.6	+8.8	−6.0	−2.7
	N	−5.2	−3.4	+12.1	−5.3	−3.9	+1.6

Character	Spacing	Semi-prostrate			Prostrate		
		group I	group II	group III	group I	group II	group III
Plant height	W	−4.9	−5.9	−0.9	+6.4	+0.4	−9.0
	N	−7.5	+4.4	+3.1	+3.2	+2.1	−7.1
Green yield	W	+1.4	+9.8	+11.1	+9.0	+5.9	−19.4
	N	−10.0	+4.7	+5.3	+6.0	+11.0	−41.1
Number of stems	W	+2.5	+5.3	−7.7	+7.4	+10.5	−24.1
	N	−4.1	+10.3	−5.3	+6.4	+8.9	−19.5
Dry matter yield	W	+2.9	+12.5	−11.9	+12.6	+2.4	−21.1
	N	−11.6	+8.5	+3.5	+9.7	+8.5	−2.3
Dry stem weight	W	+1.4	+12.6	−14.0	−4.2	+4.7	−12.5
	N	−12.6	+6.5	+5.6	+11.2	+10.0	−27.1
Dry leaf weight	W	+4.9	+12.3	−17.2	+12.9	+0.4	−16.7
	N	−10.0	+9.5	+0.8	+7.9	+6.7	−18.8

Group I = selections under wide spacings
Group II = selections under medium spacings
Group III = selections under narrow spacings

which showed a reduction, which was greater under wide than under narrow spaced-planting.

Groups I and II from prostrate types showed positive deviations when investigated under the two systems, with different degrees of superiority for the different characters. The exception was the stem yield in group I which was inferior by −4.2% when tested under wide spacing and was superior by +11.2% under narrow spacing.

Discussion

It has been demonstrated that variation of plant characters due to competition must be taken into account so far as they are affected by inter-genotypic competition (SAKAI 1955). The results obtained in this study indicate that the degree of variability in the characters differs with the growth habit type under the two space-planted systems. Thus, all characters except the number of stems, were less variable when examined under wide spacing because of the absence of this portion of variance due to competition. These results are in line with those of ROTILI—ZANNONE (1971) in lucerne and of STERN (1965) in subterranean clover.

The variables studied showed different degrees of variability under the two types of testing. Plant height was the least variable character, while dry stem weight showed the maximum variability under narrow spacing. In conclusion, dry stem weight was affected more by competition than plant height, when the spaced plants are taken as reference. These results are in agreement with SAKAI (1955), who found that plant height was the least susceptible character in rice and barley populations under competitive conditions. Also, similar results were reported in lucerne by ROTILI—ZANNONE (1970). Genetic C.V. as well as phenotypic C.V. increased under narrow spaced-planting in comparison with that obtained under wide spaced-planting. Similar results were reported in ladino clover by SYAKUDO—YASUMURO (1968).

Great differences were observed between the ranks of strong genotypes which were better able to show their ability to compete under narrow than under wide spacing. It can be suggested that the strongest genotypes under wide spacing are unlikely to remain the strongest under narrow spacing where an aggressive degree of competition exists. Certain clones behaved relatively better under the two evaluation techniques. Similar results were reported in other forage crops (AHLGREN *et al.* 1945, LAZEMBY 1957).

The number of stems in the case of erect habit type, which has a lower number of tillers per plant than the other three types studied, was not affected under wide spacing by the positive correlations obtained between neighbouring genotypes in the three replications. On the other hand, three negative values of correlation were computed in the three replications under narrow space-planting. The number of stems for the more strongly tillering types (semi-erect, semi-prostrate, and prostrate) was affected to different degrees under the two space-planted systems.

Dry matter yield was the least resistant character to competition effect for all the four types studied. These results are in good agreement with those reported by ROTILI—ZANNONE (1970), who concluded that the number of stems was more susceptible to competition than plant height and less susceptible than dry matter yield. Most of the correlations for dry matter yield between

neighbouring rows were positive under wide spacing and negative under narrow spacing. This means that the increasing space-planted area between neighbouring genotypes reduced the appearance of competition as a source of variability.

The performance of dry leaf weight showed a similar tendency to that of dry matter yield, while the dry stem weight had a different performance in 4 out of 12 cases. These results showed that the dry stem weight was a weak competitor compared to the dry leaf weight; stem thickness was one of the most important factors affecting the dry matter yield. When selected plants, in three groups each selected under a certain space area, were compared with the general mean for the three selected groups, the deviation of the mean of stem number for group I of the erect type from the general mean was not in agreement with that for stem weight. The number of stems for the other two groups had negative deviations from the general mean under both systems, while the dry matter yield was superior in spite of the inferiority of the stem number under narrow spacing. These results give a strong impression of the importance of the stem thickness of the selected genotype under wide spacing when transplanted or sown under narrow or drill conditions.

It may accordingly be expected from the results obtained for the number of stems and stem weight that selection for parent clones on the basis of dry matter yield under wide spacing depends mainly upon the number of thick stems, as well as upon plant height, which is only slightly affected by competition, while the stem thickness will be considerably different under narrow spacing or drill conditions than it is under wide spacing. On the other hand, selection for dry yield under narrow spacing will depend upon thin stem and plant height; these two characters will remain nearly the same in mass seeding or close spaced-planting.

Therefore, selection for parent clones under narrow spacing will be effective, because different variables affecting forage yield will not be completely different under similar conditions. The performance of clones selected under wide spacing will remain good when sown or transplanted in wide spacing, but when they are changed from spaced to drill conditions they will differ very markedly.

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STUDY ON THE AMINO ACID SUPPLIES OF YOUNG HUNGAHIB PIGS

By

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Investigations were made into the lysine requirements of the Hungahib pig and the Hungarian white meat-type pig. It was found that the Hungarian white meat-type pig required 0.8 per cent lysine in the first phase of fattening, depending on the protein content of the feed, while in later phases of fattening it was sufficed with 0.6 per cent lysine. In the case of a feed mixture of similar composition the lysine requirement of the Hungahib pig was higher, even exceeding 1.0 per cent. Between the nitrogen retention values obtained in the examinations of nitrogen turnover and the lysine content of the blood plasma mathematically proved correlations were found. The correlation between the free lysine content of the blood plasma and the nitrogen retention values was $r = 0.8268$, while between the lysine content of the feed and the nitrogen retention, $r = 0.9716$. Similarly intensive correlation was shown by the lysine consumed with the feed and the lysine content of the blood plasma, where $r = 0.8865$.

Introduction

An important problem of pig feeding at present is the adequate and economical protein and amino acid supply of the animals, with special regard to their lysine requirements. In trying to solve the problem some important factors have to be taken into account in every case, such as the breed, the age of the animals, the keeping conditions, etc. They fundamentally influence the amino acid requirements of pigs, and thereby the results of the experiments. The workers of our Institute developed in several years of research work a high productivity intensive hybrid pig which was given the name Hungahib. In our present experiments we made comparative studies on the lysine requirements of the Hungarian large white meat-type pig and the Hungahib pig.

Material and Method

The Hungahib pigs and the Hungarian large white meat-type pigs were fed in three groups each with feeds of different protein content and within it of different lysine concentration. The crude protein content of fodder mixtures marked "A" was 17 per cent in which 0.8 per cent (group III), 0.9 per cent (group I) and 1.1 per cent (group II) lysine was supplied, while the "B" fodder mixture, beside a 14 per cent crude protein content, had lysine concentrations of 0.6 per cent (group III), 0.9 per cent (group I) and 1.2 per cent (group II). Both the "A" and "B" feeds had a starch value of 73 kg/q. The compositions and nutrient contents of feeds are presented in Table 1.

Table 1

Composition and percentage nutrient content in feeds

Feed	"A"			"B"		
	I	II	III	I	II	III
Corn meal	40.0	40.0	40.0	40.0	40.0	40.0
Wheat meal	43.5	43.3	43.6	48.3	48.0	48.6
Fish meal	6.0	6.0	6.0	3.0	3.0	3.0
Extr. soymeal	8.0	8.0	8.0	6.0	6.0	6.0
Feed lime	0.5	0.5	0.5	0.5	0.5	0.5
Foszkal (Phylaxia)	0.5	0.5	0.5	0.5	0.5	0.5
Feeding salt	0.4	0.4	0.4	0.4	0.4	0.4
Vitamin premix (Phylaxia)	0.5	0.5	0.5	0.5	0.5	0.5
Mineral premix (Phylaxia)	0.5	0.5	0.5	0.5	0.5	0.5
L-lysine supplement	0.1	0.3	—	0.3	0.6	—
Total	100.0	100.0	100.0	100.0	100.0	100.0
Crude protein, %	17.0	17.0	17.0	14.0	14.0	14.0
Starch value, kg/q	73	73	73	73	73	73
Total lysine, %	0.9	1.1	0.8	0.9	1.2	0.6
Total methionine, %	0.3	0.3	0.3	0.3	0.3	0.3

In our small-scale group experiment the fodder mixtures were fed to 25 animals per group (a total of 150 animals). The nitrogen turnover examinations were made with animals placed individually in metabolism pens.

Feeds marked "A" were consumed by the animals until they reached an average live weight of 60—65 kg, then the lower protein content "B" feeds were fed up to the attainment of 95 kg live weight. During the experiments the weight gain of animals was checked by a monthly weighing, and the feed conversion was determined for the whole phase of the experiment. From the animals included in the group experiment — from 5 of each group — blood samples were taken once every month, while from the individually kept pigs blood was taken at the end of each experimental phase. The blood sampling was carried out according to NORDSTROM *et al.* (1970). From the blood samples the total protein, total amino acid and the rest nitrogen content (RN) were determined on the basis of a description by BÁLINT (1962), and the lysine concentration with the method of MOORE—STEIN (1954), MOORE *et al.* (1958) and DÉVÉNYI (1968, 1969). A detailed description of the blood tests has already been given in a previous paper (JÉCSAI *et al.* 1974).

Results

The fattening results of our group experiments carried out with Hungarian large white meat-type pigs are summed up in Table 2. The data show that when giving a feed mixture of 17 per cent crude protein content (diet "A") the highest weight gain (662 g/day) and best feed conversion (1 kg weight gain from 3.13 kg feed mixture) could be attained with a lysine content of 0.8 per cent. In a later phase of fattening a 0.6 per cent lysine concentration of the 14

Table 2

*Average fattening results of the Hungarian large white meat-type pig**

Feed	Group	Daily weight gain, g	Amount of feed used for 1 kg weight gain, kg
"A" feeds given between the weight limits of 31 and 65 kg	I	614	3.14
	II	640	3.38
	III	662	3.13
"B" feeds given between the weight limits of 31 and 65 kg	I	548	2.98
	II	600	2.97
	III	618	2.82

* Over a month Aujeszky' disease.

per cent crude protein content feed (diet "B") proved sufficient to attain the best weight increase and feed conversion. The most favourable feed conversion (2.82 kg for 1 kg weight gain) was obtained with animals fed on the diet B/III.

During the experiments the total protein content of the blood plasma ranged between 7.8 and 9.0 g per cent. The total amino acid-nitrogen content was an average of 14 mg/100 ml in the animals consuming feeds marked "A", and an average of 12.5 mg/100 ml in the groups fed on diet "B". The concentration of the RN in the blood plasma was found to be 29 mg/100 ml when diet "A", and 25 mg/100 ml when diet "B" was fed.

No significant difference in the total protein content of the blood plasma, the total amino acid-nitrogen content and the concentration of the RN was thus found between the animal groups given feed mixtures of different protein content.

The results of nitrogen turnover experiments carried out with Hungahib pigs are given in Table 3. Accordingly, whenever the lower protein content "B" feed mixture was given a higher nitrogen retention was obtained than when

Table 3

Daily average nitrogen retention in Hungahib pigs (g)

Group of animals	"A" feeds			"B" feeds		
	I	II	III	I	II	III
I	33.1	38.9	35.0	34.6	39.0	31.1
II	19.1	23.5	14.0	40.9	36.5	32.9
III	27.2	38.2	34.3	37.2	37.8	31.4
IV	35.0	33.5	27.5	26.5	43.4	33.0
$\bar{x}$	28.6±7.1	33.6±7.1	27.8±6.1	34.8±3.0	39.2±3.0	32.1±0.9

feeding the "A" diet. The highest nitrogen retention both with the "A" and "B" diet was attained with a lysine content of 1.1 and 1—2 per cent, respectively. The "A"/II feed resulted in a 33.6 g/day, while the "B"/II feed in a 39.2 g/day nitrogen retention. This means that our hybrid pig is able to convert more than 1 per cent lysine.

In our previous investigations (SZELÉNYI *et al.* 1973) we found that with the Hungarian large white meat-type pig an average of 20 g daily nitrogen retention could be attained with a feed mixture containing 0.9 per cent lysine. A young Hungahib pig, on the other hand, is able to retain an average of 35 g nitrogen a day with the same lysine content feed.

Changes in the lysine content of the blood plasma are shown in Table 4. In the animals of groups I and II the average lysine content of the blood plasma did not show any significant change with either the "A" or the "B" feeds. Since any substantial difference in the lysine content of the feed was only found in those marked A/III (0.8 per cent lysine content) and B/III (0.6 per cent lysine content), therefore in the blood plasma of these groups the lysine concentration also showed an essential difference. In the animals of group "A" 25.6, while in those of group "B" 20.1 μMol lysine was measured. The difference between the two values is significant ($p < 0.001$).

Table 4

Changes in the lysine content of the blood plasma in Hungahib pigs

	Groups		
	I	II	III
"A" feeds	28.8±1.4	38.5±0.2	25.6±1.7
"B" feeds	28.7±1.7	37.9±4.7	20.1±2.0

Conclusions

The above results confirm our earlier findings (SZELÉNYI *et al.* 1973, 1975) that when a feed of constant energy content is consumed, within the protein and amino acid content of the feed mainly the amount of lysin plays the decisive role in the weight gain and feed conversion of pigs. From the results of our experiments we can draw the conclusion that the crude protein content in the feed of the Hungarian large white meat-type pig can be reduced to 14 per cent or even less if a lysine concentration of 0.9 per cent is ensured in the diet.

In the initial phase of fattening the Hungarian large white meat-type pig requires 0.8—0.9 per cent lysine in the feed depending on the protein content of the diet; in the later phases 0.6 per cent lysine is sufficient.

Experiments performed with the Hungahib pig have revealed that this intensive hybrid has an essentially higher lysine requirement (about 1.0 per cent) than the Hungarian large white meat-type pig.

Between the nitrogen retention values obtained in the course of investigations into the nitrogen turnover, and the lysine content of the blood plasma mathematically proved correlations were found. The correlation between the

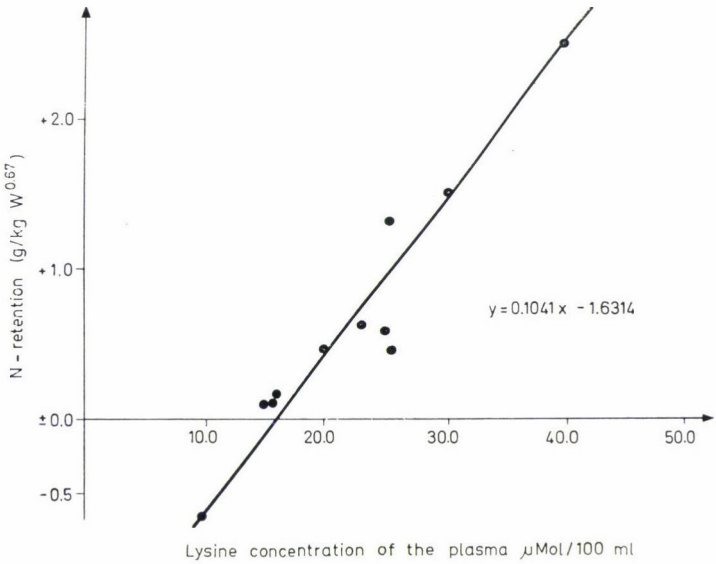

Fig. 1. Relationship between the lysine content of the blood plasma and the nitrogen retention

free lysine content of the blood plasma and the nitrogen retention values was $r = 0.8268$ (Fig. 1). A similarly close correlation was found between the lysine content of the feed and the nitrogen retention of pigs (Fig. 2), with $r = 0.9716$. The relationship was intensive between the amount of lysine consumed with the feed and the lysine content of the blood plasma — $r = 0.8865$ (Fig. 3). On the basis of the correlations seen in Figs 1, 2 and 3 it can be established that the amount of lysine supplied in the feed decidedly influences the free amino acid content of the blood plasma and the amount of nitrogen retained in the organism. Furthermore, the above correlations show that inasmuch as the lysine content of the blood plasma increases, the nitrogen balance rises in a positive direction, that is, the organism is able to retain more nitrogen. Thus the effect of the lysine content of feed on the lysine concentration of the blood plasma is similar to that exerted on the nitrogen retention. The correlations calculated on the basis of our experimental results suggest that both the positive direction shift of the nitrogen balance and the measuring data of the free

amino acid content of the blood plasma — maintaining the prescribed conditions — provide a firm basis on which to determine the lysine requirements of pigs.

Another conclusion drawn from our experiments is that an adequate amount of synthetic lysine supplied in a well composed diet can be utilized by the organism in the same way as lysine given in a protein-bound form.

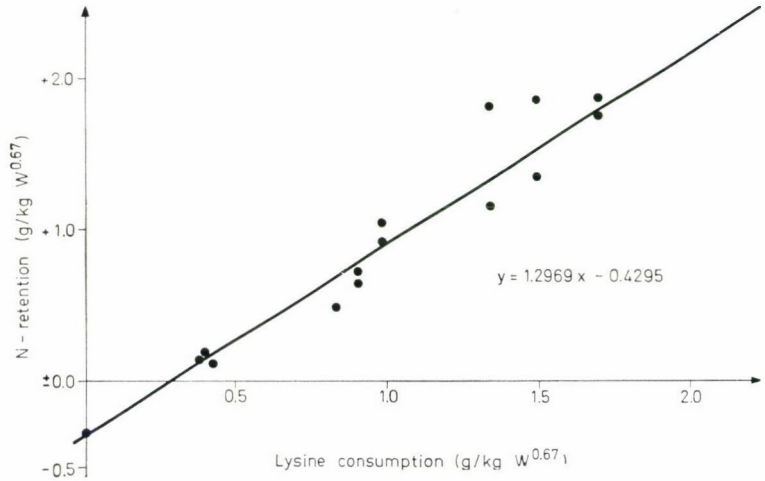

Fig. 2. Relationship between the nitrogen retention and the lysine uptake

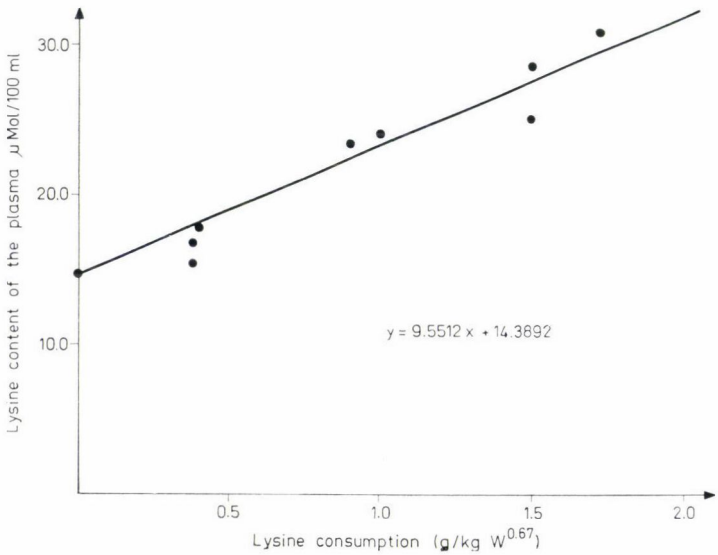

Fig. 3. Relationship between the lysine content of the blood plasma and the lysine uptake

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VARIA

GROWTH MEASUREMENTS OF HUNGARIAN FLECKVIEH × CANADIAN HOLSTEIN FRIESIAN ♂ (F_1), AND HUNGARIAN FLECKVIEH × JERSEY ♂ (F_1) BULLS

The surface body measurements of animals were investigated by several workers (BRODY 1945, JOUBERT 1954, DAVIS—HATHAWAY 1955, 1959, HORN *et al.* 1960, FARRAG 1971). These measurements provide records for the normal development of animals and thereby can be used as estimations for the prediction of the conformation, size, age and sex of the normal individuals. Also, measurements taken on various parts of the body furnish an objective description of body conformation, which is one of the most important bases in judging and selecting for breeding and production purposes.

The present study is a preliminary effort to evaluate certain body measurements as predictors of the subsequent growth rate of the body parts of the two new crossbred types of Hungarian Fleckvieh ♀ × Canadian Holstein Friesian ♂, F_1 and Hungarian Fleckvieh ♀ × Jersey ♂, F_1 bulls.

The data used for this study were obtained from two equal groups of 14 bulls, born at the Szentegát State Farm (Hungary). These bulls were selected at random from the crossbred herd of Hungarian Fleckvieh × Canadian Holstein Friesian (HF × CHF) F_1, group I, and Hungarian Fleckvieh × Jersey (HF × J), F_1, group II.

The two groups of animals were kept loose in two separate pens. Rations of similar composition were offered to the two groups during the whole experimental period. After suckling the colostrum and the mother-milk, the rations fed consisted of commercial dry-milk and calf-starter, till 102 days of the animal's age. Then alfalfa-hay, molass and concentrated feed were offered ad libitum till the end of the experimental period. For more details of general feeding and management reference should be made to an earlier paper (FARRAG 1971).

The live weights and the following body measurements were recorded as described by DAVIS—HATHAWAY (1955): at birth, 3, 6, 9, 12 and 15 months of age.

1. Length of body: from the front of the shoulder point to the rear of the spine bone.
2. Height at withers: the vertical distance from the ground to the highest level of the shoulder blade.
3. Depth of chest: the vertical distance from the top of the spinal column just behind the shoulder blade to the lower surface of the breast-bone.
4. Girth of chest: the girth of chest across the fifth or the sixth thoracic vertebra, measured by tape.
5. Width of chest: the horizontal width of the chest just behind the shoulder blade across the fifth or the sixth thoracic vertebra.
6. Width between thurls: the horizontal distance between the extreme of the femur knobs.
7. Length of rump: the distance from the hip bone to the rear of the spine bone.
8. Girth of metacarpal bone: the circumference of the fore metacarpus approximately midway between the knee and the pastern.

In order to eliminate, as much as possible, the variations caused by changes in the position of each animal, the body measurements during all the experimental period were taken by the same person in triplicate and averaged. Also it must be pointed out that the body measurements at birth were not taken from all the experimental animals, but from only 5 animals of group I, and 6 animals of group II.

The data regarding the live weights and body measurements of the experimental animals in the two groups were coded and punched on cards for further analysis using the electronic computer at the Animal Physiology Department, University of Veterinary Science, Budapest. The mean values, standard errors, and standard deviations were applied as suggested by SNEDECOR (1956).

The means, standard errors and standard deviations of the live weight and body measurements at birth, 3, 6, 9, 12 and 15 months of age of the two groups of experimental animals are presented in Table 1. Fig. 1 shows the linear body measurements of the crossbred bull groups from birth till the end of the experimental period. It could be observed that the body measurement of the two groups showed an increase with advancing age and increasing live weights. At birth the HF × CHF bulls (group I) were 5.79 ± 0.72 kg heavier than the HF × J bulls (group II); at the same time all the body measurements of group I were larger than those of the animals of group II. Also for each age period thereafter the animals of HF × CHF exceeded those of the HF × J bulls in body size.

It is important to compare the mean body measurements of the two groups at birth and at the end of the experimental period. Nearly identical differences were found between the two groups of bulls at birth and at 15 months in height at shoulder, width of chest, width between thurls and girth of metacarpal bone, while differences in body length, length of rump, as well as girth and depth of chest of the two groups of animals were increased at the end of the experimental period, except the body length which was reduced.

In order to study the developmental changes in the body size of the two groups of animals, the mean percentage increases in the body dimensions from birth to an average age of 15 months has been calculated after JOUBERT (1954). The calculation of the total development is based on the assumption that the animals were fully grown for fattening at the end of the 15th month. Table 2 shows the mean percentage increases and differences in percentage increases of the body measurements from birth till 3, 6, 9, 12 and 15 months of age of the two groups of animals. The mean percentage increases from birth onwards relative to the birth dimensions indicate that the body dimensions of HF × J (group II) developed faster than those of HF × CHF (group I) with the exception of the body length (from birth to 3 months) and the chest depth (from 9 to 12 months), which developed slightly slower in group II than in group I.

Also data in Table 2 indicate that with the exception of the chest depth (from 9 to 12 months), rump length (from 3 to 6, and from 12 to 15 months) of group I and chest girth and height at shoulder (from 6 to 9 months) of group II, the percentage increases of the respective dimensions of the two groups of animals show a faster post-natal increase (from birth till 3 months of age), which continues at a comparatively slightly lower level till the end of the experimental time.

A faster post-natal increase (from birth till 9 months), which largely reduces thereafter till the end of the experimental period, can be observed (Table 2) in body length, chest width and girth of metacarpal bone of the two groups of experimental animals.

Similarly, the width between thurls of the two groups showed faster increases (from birth to 6 months of age), but these increases lowered till the age of 12 months thereafter a high level of increase in this dimension was found till the end of the 15th month of age.

As it was found earlier by JEFFERY—BERG (1973), the breed difference is responsible for the high level of variance in growth, as well as for the fact that the heavier calves at birth

Table 1

*Means ± standard errors and standard deviation of the live body weights and body measurements at birth, 3, 6, 9, 12, and 15 months of age in the two groups of animals**

Traits	Groups	At birth		At 3 months		At 6 months	
		$x \pm$ S.E.	S.D.	$x \pm$ S.E.	S.D.	$x \pm$ S.E.	S.D.
Live body weight (kg)	I	34.57±2.01	7.56	122.14±3.46	12.97	242.50± 6.22	23.27
	II	28.78±1.29	4.84	109.64±4.76	17.81	214.64± 9.57	35.81
Length of body (cm)	I	68.20±1.32	2.95	91.07±0.98	3.67	113.36± 1.52	5.69
	II	60.83±1.89	4.62	89.78±1.27	4.76	109.93± 1.79	6.70
Height at withers (cm)	I	76.40±2.25	5.03	92.14±0.60	2.25	105.43± 1.05	3.92
	II	67.67±2.67	6.53	86.86±1.25	4.67	97.36± 1.15	4.29
Depth of chest (cm)	I	29.00±1.30	2.91	40.68±0.54	2.03	50.07± 0.57	2.13
	II	26.83±1.27	3.12	39.57±0.54	2.03	48.00± 0.65	2.42
Girth of chest (cm)	I	78.80±1.80	4.02	111.50±1.39	5.21	143.07± 1.81	6.76
	II	71.83±1.54	3.76	106.21±1.67	6.26	133.36± 2.27	8.50
Width of chest (cm)	I	18.00±0.32	0.71	25.21±0.63	2.36	32.43± 1.00	3.73
	II	13.83±0.87	2.14	22.57±0.86	3.23	27.86± 1.18	4.43
Width between thurls (cm)	I	21.40±0.51	1.14	27.86±0.37	1.41	36.50± 0.50	1.87
	II	17.16±1.25	3.06	25.57±0.57	2.14	32.57± 0.81	3.03
Length of rump (cm)	I	24.20±0.49	1.09	31.64±0.36	1.34	40.12± 0.54	2.01
	II	21.33±0.56	1.37	30.71±0.70	2.61	38.50± 0.75	2.79
Girth of metacarpal bone (cm)	I	11.80±0.20	0.44	13.21±0.19	0.70	15.64± 0.17	0.63
	II	10.67±0.21	0.52	12.83±0.14	0.51	14.86± 0.25	0.95

Traits	Groups	At 9 months		At 12 months		At 15 months*	
		$x \pm$ S.E.	S.D.	$x \pm$ S.E.	S.D.	$x \pm$ S.E.	S.D.
Live body weight (kg)	I	361.78±6.47	42.99	473.93±8.55	32.00	578.21±11.49	42.99
	II	325.71±9.31	34.85	410.00±9.12	34.14	494.28±11.59	43.36
Length of body (cm)	I	135.71±1.15	4.32	142.71±1.49	5.57	150.07± 1.35	5.06
	II	132.43±1.44	5.40	137.50±1.58	5.91	145.78± 1.44	5.39
Height at withers (cm)	I	119.43±1.16	4.34	126.14±0.98	3.68	131.93± 0.97	3.65
	II	111.78±1.19	4.46	118.93±1.02	3.81	123.50± 1.39	5.20
Depth of chest (cm)	I	56.00±0.89	3.33	63.43±0.61	2.28	68.00± 0.64	2.38
	II	53.64±0.51	1.90	58.43±0.98	3.65	63.50± 0.48	1.79
Girth of chest (cm)	I	171.36±1.44	5.39	185.78±2.02	7.57	196.78± 1.61	6.01
	II	162.07±2.12	7.92	176.28±1.64	6.14	183.36± 1.80	6.74
Width of chest (cm)	I	42.07±0.91	3.41	46.93±0.65	2.43	47.00± 0.65	2.42
	II	37.14±0.92	3.46	41.86±0.71	2.66	42.50± 0.63	2.38
Width between thurls (cm)	I	38.50±0.72	2.68	41.00±0.56	2.11	48.57± 0.48	1.78
	II	34.78±0.69	2.58	35.07±0.46	1.73	42.93± 0.69	2.55
Length of rump (cm)	I	45.36±0.67	2.50	48.36±0.49	1.82	53.78± 0.97	3.62
	II	43.50±0.68	2.53	46.50±0.46	1.74	49.12± 0.50	1.89
Girth of metacarpal bone (cm)	I	19.14±0.25	0.95	20.71±0.22	0.82	21.07± 0.19	0.73
	II	17.64±0.29	1.08	19.28±0.19	0.73	19.64± 0.20	0.74

* Group I: Hungarian Fleckvieh × Canadian Holstein Friesian F_1; Group II: Hungarian Fleckvieh × Jersey F_1

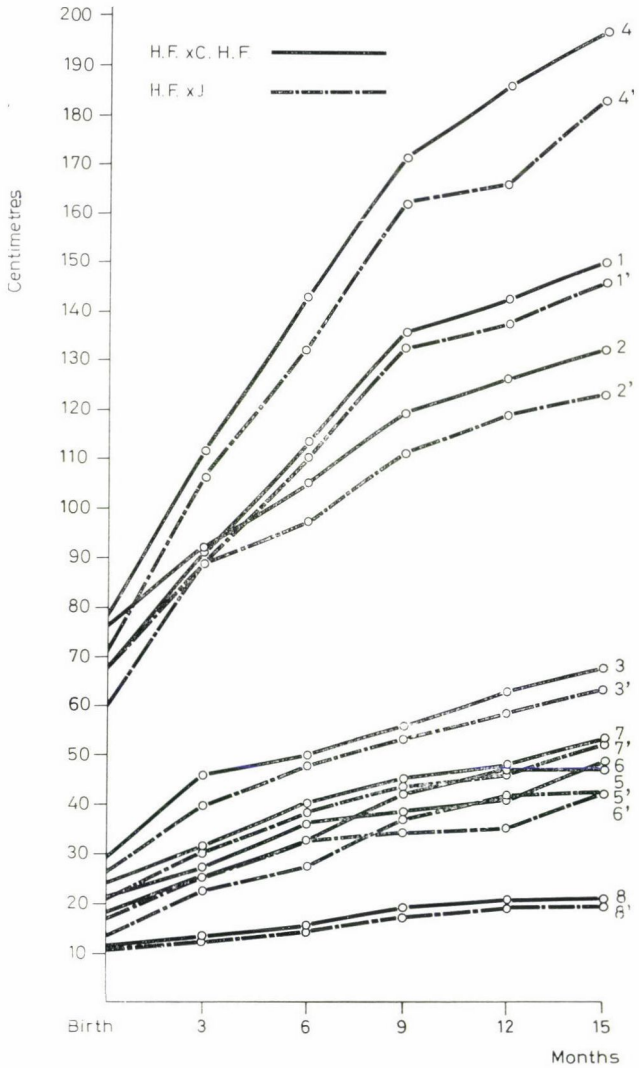

Fig. 1. Linear body measurements for HF×CHF and HF×J crossbred bulls from birth to 15 months by three-month intervals (1, 1' Length of body. 2, 2' Height at withers. 3, 3' Depth of chest. 4, 4' Girth of chest. 5, 5' Width of chest. 6, 6' Width between thurls. 7, 7' Length of rump. 8, 8' Girth of metacarpal bone)

tended to exceed in growth during the live period. The present results in Table 1 regarding the live weight and body dimensions of the two groups of animals indicate that the bulls of Hungarian Fleckvieh×Canadian Holstein Friesian were heavier in absolute body weight and larger in body dimensions from birth till the end of the experimental period than those of Hungarian Fleckvieh×Jersey bulls.

The relative increases in body weights and dimensions to the birth weight and size of the Holstein Friesian, Ayrshire, Guernsey and Jersey bulls were studied earlier (DAVIS—

Table 2

*Mean percentage increases and differences in percentage increases of body measurements from birth till 3, 6, 9, 12 and 15 months of age in the two groups of animals**

Traits	Groups	3 months		6 months		9 months		12 months		15 months	
		increase	difference	increase	difference	increase	difference	increase	difference	increase	difference
Length of body	I	33.53	33.53	66.22	32.69	98.99	32.76	109.25	10.26	120.04	10.79
	II	31.15	31.15	80.72	49.57	117.70	36.98	126.04	8.34	139.65	13.61
Height at withers	I	20.60	20.60	38.00	17.40	56.32	18.32	65.10	8.78	72.88	7.58
	II	28.36	28.36	43.87	15.51	65.18	21.31	75.75	10.57	82.50	6.75
Depth of chest	I	40.27	40.27	72.27	32.00	93.10	20.83	118.72	25.62	134.48	15.76
	II	47.48	47.48	78.90	31.42	99.92	21.02	117.78	17.86	136.67	18.89
Girth of chest	I	41.50	41.50	81.57	40.07	117.46	35.89	135.76	18.30	149.76	14.00
	II	47.86	47.86	85.66	37.80	125.63	39.97	145.41	19.78	155.27	9.86
Width of chest	I	40.05	40.05	80.17	40.17	133.72	53.55	160.72	27.00	161.11	0.39
	II	63.19	63.19	100.00	36.81	168.55	68.55	202.67	34.12	207.30	4.63
Width between thurls	I	30.19	30.19	70.56	40.37	79.91	9.35	91.59	11.68	126.96	35.37
	II	49.00	49.00	89.80	40.80	102.68	12.88	104.37	1.69	150.17	45.80
Length of rump	I	30.74	30.74	65.78	35.04	87.44	21.66	99.83	12.39	122.23	22.40
	II	44.50	44.50	80.50	36.00	103.94	23.44	118.00	14.06	130.28	12.28
Girth of metacarpal bone	I	11.95	11.95	32.54	20.59	62.20	29.66	75.51	13.31	78.56	3.05
	II	20.24	20.24	39.27	19.03	65.32	26.05	80.69	15.37	84.07	3.38

* Group I: Hungarian Fleckvieh × Canadian Holstein Friesian; Group II: Hungarian Fleckvieh × Jersey.

HATHAWAY 1959). It was found that the greastest relative gain in weight and body size were shown by the Jersey breed, the rump length and chest width were greater only during the first nine months in the Holstein Friesian breed. Similarly, it seems that the Jersey breed is responsible for the faster increase in the relative body weights and measurements from birth onward in the Hungarian Fleckvieh × Jersey crossbred bulls, than those of Hungarian Fleckvieh × Canadian Holstein Friesian crossbred bulls.

The present result shows that more than half of the total growth in the body length, height at shoulder and girth of metacarpal bone were already completed at six months of age. It could be concluded that the percentage increases from birth onward indicate that these dimensions were relatively early maturing. This result supports the conclusion of BRODY (1945) and FARRAG (1971) that these are relatively early maturing skeletal measurements.

Also Table 2 shows fast post-natal increases in the three chest dimensions (girth, width and depth) through the first three months in the two groups of experimental animals. As it was pointed out earlier by HAMMOND (1932), the ribs in the live animals are held in position by muscles and the degree of development is an important factor determining the spring of the ribs. Highly muscular development in the region of the fifth and sixth ribs could be noted (Table 2) from birth till 12 months of age in both experimental groups.

Similarly high percentage increases were found in the chest girth of the two groups of animals from birth to the ninth month. BRODY (1945) reported that chest girth has a comparatively rapid rate of postnatal growth and is slower in reaching maturity than most other body measurements.

It could be observed that the high percentage increases in the three chest dimensions from birth onwards indicate that these measures must rank among the late maturing dimensions.

Since the hind quarters contain the most valuable cuts from the producers' and butchers' points of view, the width between thurls and the rump length particularly in relation to other body proportions could be considered as important measures of potential muscular development. Only about 20 per cent of the total development in the width between thurls happened through the last three months in the two groups of experimental animals. However, more than half of the development in the preceding two dimensions were completed at six months of age. So it could be reported that the post-natal development of the two cross-bred types of experimental animals do not fully support the views of the producers and butchers.

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FIVE YEARS' RESULTS OF INVESTIGATIONS ON POWDERY MILDEW IN WHEAT AT MARTONVÁSÁR (1971—1975)

I. Physiological specialization

At the end of the fifties the standard of wheat growing in Hungary changed considerably. According to RAJKI (1960) this was due to the introduction of new varieties in commercial production, the application of new large-scale cultural practices and the general use of high rate fertilization. All this promoted the mass appearance and spread of a number of wheat diseases, among others *Erysiphe graminis* DC. f. sp. *tritici* Marchal. It has thus become necessary to study this pathogen in detail.

Powdery mildew is a pathogen generally specific to the host plant. Its biological forms (formae speciales), which are completely identical morphologically and only differ in their primary and secondary hosts, were determined first of all on the basis of experiments carried out by MARCHAL (1902) and SALMON (1903). Powdery mildew has 33 biological forms (KARTOSKINA 1964). One of them is *Erysiphe graminis* DC. f. sp. *tritici* Marchal, a parasite of wheat and wheat-grass. Even these biological forms are not uniform but undergo further specialization within the main host plant. These forms are called races and are identified by means of a test sortiment (NOVER 1957, LEIJERSTAM 1965, WOLFE 1967, SZUNICS—SZUNICS 1972).

Powdery mildew was obtained from various varieties sown on the experimental area. In identifying the races we used the method of NOVER (1957). During the experiment the temperature in the greenhouse was 16—20°C and the relative humidity 50—90%.

During the past five years 638 pure cultures have been produced, from which 38 races were identified. Of the isolated races 11 were found in all the years, 5 in three years, 11 in two years and 7 in one year of the period in question (Table 1).

The annual occurrence of the prevalent races (4, 26, 9, 52, 2) is similar, though certain differences can be observed. This does not, however, contradict the literary data (BÓCSA 1968, VORONKOVA—SIDORINA 1974).

The races may differ in frequency. Races 13 and 18, for example, were isolated in similar percentages every year. The population numbers of races 0 and 14 vary from year to year. The proportions of races 26 and 52 are increasing.

The most virulent races in the Martonvásár population are: 33, 46, 47, 48, 52, 53. Of the 38 races isolated 28 are less virulent and amount to 84.22% of the race population. The 10 virulent races occur only in 15.78%. The virulent races were isolated 5.3 times less

Table 1

Percentage distribution of the race spectrum

Isolated races	Years				
	1970/71	1971/72	1972/73	1973/74	1974/75
0	10.00	3.33	12.45	4.57	0.61
1		0.66	0.83		
2	2.00	6.66	4.92	3.92	8.54
3	14.00	2.66	8.30	5.88	
4	2.00	11.38	13.28	18.95	18.91
5	8.00	3.99	0.83		
7	6.00	5.99	1.66	1.96	1.22
8					0.61
9	14.00	3.99	11.62	9.15	6.10
10				3.92	0.61
11		0.66		1.32	
13	4.00	5.99	6.56	3.92	1.83
14	2.00	8.69	9.02	3.26	1.83
15		4.67			1.22
16	4.00	1.99			0.61
17		0.66	0.83		
18	2.00	6.66	2.48	1.32	1.83
19		2.66			
21		2.66	0.83		
22		0.66			
24	2.00				
26	2.00	9.99	5.74	10.45	25.61
27	4.00	5.99	0.83	1.32	
28		0.66		1.32	
29			0.83	0.65	
30			1.66	0.65	
31	2.00		0.83	3.92	1.83
32	4.00	1.33	1.66	1.32	10.36
33					0.61
35	8.00			1.32	1.83
40			0.83		1.22
43					0.61
44		0.66	0.83		0.61
46	10.00	2.66	1.66	0.65	2.43
47		1.99		1.30	0.61
48		1.33		2.61	
52		1.33	9.86	16.32	10.36
53			1.66		
Number of pure cultures produced	50	150	121	153	164
Number of isolated races	18	27	24	23	23
Pure culture/race	2.77	5.55	5.04	6.65	7.13
Race/pure culture	0.36	0.18	0.19	0.15	0.14

frequently. There is thus a negative correlation between the virulence and distribution of the races of wheat powdery mildew. VAN DER PLANK (1968) arrived at the same conclusion in the case of potato phytophthora and wheat stem rust.

The large number of isolated races can be explained primarily by the wide range of varieties from which the powdery mildew was collected. Owing to the great variation of host plants the variability of the pathogen is generally much higher in the breeders' test plots than

Table 2

Reactions of varieties in a test sortiment to five new races of wheat powdery mildew

Test sortiment	Resistance factor	Races				
		46	47	48	52	53
Carsten V	absent	S	S	S	S	S
Salzmünde st. 1444	ml_r	S	S	S	S	S
Red Fern	Pm 2	S	S	S	S	S
Axminster	Pm 1	S	S	R	S	S
Halle st. 13 471	Pm 2 + Ml_d	R	S	S	R	R
Weihenstephan MI.	Ml_e	R	R	R	R	R
Hope sel.	pm 5	S	R	R	R	S
Chul	Pm 3b	S	S	S	S	R

in commercial production where only a few varieties are grown. A similar result was obtained by LEIJERSTAM (1965) and WOLFE (1967). At the same time an increase in the pathogen races can be observed on Neuzucht, Avrora, Kavkaz, Bezostaya 2 and their crossing progenies.

In the course of the race identifications we found five which could not be identified on the basis of their reaction patterns in the test sortiment. These pure progeny lines gave the same type of reaction after repeated examinations, therefore the possibility of mixing was excluded. We sent the result of our work to Ilse Nover who classified the isolates and furnished them with the proper serial numbers (46, 47, 48, 52, 53).

As may be seen from Table 2, races 46 and 47 are able to attack six of the eight varieties of the test sortiment, so they are the most virulent of the new races. Race 46 is characterized by avirulence to Halle st. 13 471 and virulence to the variety Hope. Race 47 displays just the opposite behaviour. The other three races attack five varieties of the sortiment each, that is, they are avirulent to three varieties. Of these varieties, Weihenstephan MI is not affected by any of the races, Halle st. 13 471 and Hope are resistant to two each (52, 53 and 48, 52, respectively), and Axminster and Chul to one each (48 and 53, respectively).

Of the 638 pure cultures examined so far, race 53 was found in two (0.31%) and 47 and 48 in six (0.94%) cases. Race 46 appeared every year, though not too frequently: on a total of 16 occasions (2.51%). Race 52 is of the greatest importance of all. It was first identified in 1971/72 and occurred twice, thus having a 1.32% share in the population of that year. Its proportion increased, however, from year to year; it was isolated 12 times (9.86%) in 1972/73, 25 times (16.32%) in 1973/74 and 17 times (10.36%) in 1974/75. Since all wheat varieties grown in Hungary are susceptible to race 52, it is potentially possible for it to multiply.

The process of race formation is known, and detailed race surveys continually demonstrate new races. It is thus necessary to know the stability of the races. Furthermore, it is important to know how virulent and viable the new races are, whether they are able to survive after the vegetation period (harvest) until the autumn when the wheat comes up, or until the next spring. If they are unable to survive, the problem is merely theoretical, but if they survive it assumes growing and breeding aspects and preventive measures must be taken.

The constancy of the range of races considerably influences the success of breeding work. In our opinion the appearance of new races does not exclude the stability of those already in existence, because the latter can survive alongside the new races. At this point our opinion

agrees with the statement of VAN DER PLANK (1968) that the appearance of the races is only one side of the problem, while their viability and the selective effect are the other.

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AGRONOMIC TREATMENTS AND CHANGES IN THE RHIZOSPHERE MYCOFLORA OF GROUNDNUT

II. Effect of commercial fertilizers

Groundnut (*Arachis hypogaea* L.) being a leguminous plant, is capable of fixing atmospheric nitrogen through the root nodule bacteria. But under the normal system of cultivation where pods are removed and the plants are taken out, the crop removes a relatively large amount of nutrients from the soil (SHESHADRI 1962). A groundnut crop is, therefore, bound to be soil depleting, unless the crop itself is directly manured with N, P and K providing fertilizers. Since the soil microorganisms play a very important role in determining soil fertility, the use of fertilizers may exert a direct influence on the soil fertility through their effects on microfungi in the rhizosphere and soil of crop plants. Effects of fertilizers on rhizosphere

and soil fungi of different crop plants have been reported (GUILLEMAT—MONTEGUT 1960, JOFFE 1963, MISHRA 1967, SUNAR—CHOHAN 1971).

In the present communication we set the aim of studying what quantitative and qualitative changes take place in the rhizosphere and soil mycoflora in plots of groundnut when they are amended with N, P and K providing fertilizers like urea, superphosphate, muriate of potash and mixed fertilizer NPK 9 : 9 : 5.

The experiment was carried out under field conditions in the University Botanic Garden on 10 × 10 m plots arranged in a randomized block design with 3 replicates. Fertilizers were applied 10 days before sowing at the following rates per hectare (KULKARNI *et al.* 1967): Urea — 75 kg N, superphosphate — 200 kg P, muriate of potash — 100 kg K and mixed manure (9 : 9 : 5) — 40 N : 40 P : 25 K.

The rhizosphere mycoflora was studied by soil dilution and the plate count method of TIMONIN (1940) using Waksman's synthetic acid agar medium (pH 4.5) at a 15 days' interval from the date of sowing to harvest. One plant was removed from each replicate. The soil mycoflora was studied by taking soil samples between two rows of the crop to the depth

Table 1

Number of fungi (10^3/g oven dry soil) in the rhizosphere of groundnut SB-11 raised in the plots treated with commercial fertilizers

Fertilizers	Age of plants in days							
	15	30	45	60	75	90	105	120
Control								
R	8.46	13.70*	5.18	14.87	19.04**	20.26	24.79	6.03
S	3.39	2.76	1.86	4.80	5.61	7.00	9.30	2.70
R/S	2.5	4.6	2.8	3.0	3.4	2.9	2.7	2.3
Urea								
R	24.30	56.41	67.00*	32.61	43.66	23.50	85.41**	90.83
S	4.82	12.89	10.50	12.63	10.87	5.00	7.91	13.22
R/S	5.0	4.5	6.4	2.5	4.0	4.8	10.8	6.9
Superphosphate								
R	97.66	55.50*	35.00	29.00	40.91**	23.83	42.98	16.00
S	8.70	7.50	10.50	21.00	14.95	16.00	15.81	7.49
R/S	11.32	7.5	3.4	1.5	2.8	1.5	2.8	1.7
Muriate of potash								
R	7.57	40.81*	22.00	30.66	23.96**	48.50	18.50	8.00
S	4.66	12.25	11.00	13.31	7.50	7.00	5.00	8.00
R/S	1.6	3.5	2.0	2.4	3.3	6.9	3.8	1.00
NPK 9 : 9 : 5								
R	7.89	6.00	41.78*	42.28	18.25	31.50**	27.00	13.00
S	4.84	4.00	11.84	15.00	11.49	7.00	9.03	9.50
R/S	1.7	1.6	3.5	2.9	1.5	4.5	2.9	1.4

* Flowering period started. ** maturation period started.

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Table 2

Effect of commercial fertilizers on the frequency of occurrence of taxonomic groups of fungi in the rhizosphere (R) and soil (S) of groundnut SB-11 (expressed as total number of colonies in thousands during the entire period of growth)

Taxonomic group	Control		Urea		Superphosphate		Muriate of potash		NPK 9 : 9 : 5	
	R	S	R	S	R	S	R	S	R	S
7 *Phycomycetes*	4.39	2.53	2.87	10.71	25.32	18.87	11.26	9.15	20.24	12.81
3 *Ascomycetes*	0.22	0.12	0.26	—	—	—	0.41	1.75	4.99	0.50
14 aspergilli	78.28	25.00	117.11	20.82	40.91	26.17	126.90	27.33	98.61	38.71
6 penicilli	10.03	3.70	220.95	40.13	255.99	40.98	45.95	19.20	58.51	12.26
4 fusaria	5.58	3.19	35.11	6.29	21.41	1.08	14.97	5.72	32.34	6.34
14 other *Deuteromycetes*	6.25	1.94	2.25	3.24	0.25	1.45	0.77	0.50	1.26	0.26

R — rhizosphere, S — soil.

Table 3

Effect of commercial fertilizers on the frequency of occurrence of dominant fungal species in the rhizosphere (R) and soil (S) of groundnut SB-11 (expressed as total number of colonies in thousands during the entire period of growth)

Species	Control		Urea		Superphosphate		Muriate of potash		NPK 9 : 9 : 5	
	R	S	R	S	R	S	R	S	R	S
1. *Rhizopus stolonifer*	5.09	2.19	5.87	4.21	22.56	18.45	9.34	7.40	19.36	12.00
2. *Aspergillus aculeatus*	4.87	3.37	8.76	3.13	0.50	0.25	6.33	1.25	4.78	2.00
3. *A. carbonarius*	66.83	26.66	22.42	5.19	14.16	11.61	34.15	9.35	39.16	13.11
4. *A. flavus*	4.73	0.53	6.00	1.13	1.75	0.50	9.75	1.00	17.49	3.75
5. *A. fumigatus* (strain I)	3.42	2.82	72.41	1.38	14.00	11.85	73.85	10.90	24.86	10.00
6. *Penicillium funiculosum* (strain I)	9.23	3.22	150.12	34.22	254.20	48.90	36.34	18.05	48.51	10.95
7. *Fusarium oxysporum*	2.56	1.03	53.73	3.71	12.50	0.25	6.99	0.82	5.25	0.68
8. *F. semitectum*	0.30	—	12.26	2.33	8.91	0.83	8.08	3.90	24.09	5.04

R — rhizosphere, S — soil.

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Table 4

Effect of commercial fertilizers on the frequency of occurrence of rare fungal species in the rhizosphere (R) and soil (S) of groundnut SB-11 (expressed as total number of colonies in thousands during the entire period of growth)

Species	Control		Urea		Superphosphate		Muriate of potash		NPK 9 : 9 : 5	
	R	S	R	S	R	S	R	S	R	S
1. *Absidia corymbifera*	0.10	—	—	—	—	—	—	—	—	—
2. *Cunninghamella echinulata*	—	—	—	—	—	—	—	—	—	0.81
3. *Mortierella* sp.	0.07	—	—	—	—	—	—	—	—	—
4. *Phytophthora marathwadensis*	—	0.12	—	—	—	—	—	—	—	—
5. *P. rubra*	1.13	0.17	—	—	—	—	1.52	1.25	—	—
6. *Syncephalastrum racemosum*	—	—	—	0.50	—	0.50	—	—	—	—
7. *Aspergillus nidulans*	—	—	0.26	—	—	—	0.41	1.75	2.85	—
8. *Chaetomium longirostrae*	0.22	0.07	—	—	—	—	—	—	—	—
9. *Penicillium brefeldianum*	—	—	—	—	—	—	—	—	2.14	0.50
10. *Aspergillus asperescens*	—	—	—	1.83	1.00	—	—	0.50	1.00	2.06
11. *A. fumigatus* (strain II)	0.82	0.50	—	0.16	1.50	—	0.50	1.50	—	—
12. *A. flavipes*	—	—	—	—	—	—	—	—	—	0.50
13. *A. kanagawaensis*	—	—	—	1.00	—	—	0.50	—	1.21	—
14. *A. niger*	1.30	2.61	2.67	2.88	3.75	0.25	1.49	1.25	3.71	5.51
15. *A. petrakii*	—	0.35	—	—	—	—	—	—	—	—
16. *A. sclerotiorum*	0.51	—	—	—	—	—	—	—	—	—
17. *A. sulphureus*	0.38	—	1.70	0.66	—	—	—	—	—	—
18. *A. terreus*	3.20	1.54	3.35	2.46	8.25	5.41	1.83	—	0.50	—
19. *A. ustus*	0.22	0.61	—	—	—	—	—	—	—	—
20. *Chaetomella raphigera*	0.12	0.05	—	—	—	—	—	—	—	—
21. *Cladosporium oxysporum*	—	0.30	—	—	—	—	—	—	—	—
22. *Curvularia lunata*	—	0.20	—	—	—	—	—	0.25	—	—

23. *Fusarium solani*	4.42	1.33	—	—	—	—	—	—	—	—
24. *F. moniliforme*	0.44	0.22	1.50	0.25	—	—	—	—	3.00	0.62
25. *Helminthosporium tetramera*	0.78	0.31	—	—	—	—	—	—	0.76	—
26. *Hormiscium bruennesporium*	—	—	0.66	—	—	—	—	—	—	—
27. *Macrophoma minuta*	0.25	—	—	—	—	—	—	—	—	—
28. *Paecilomyces varioti*	—	—	0.50	1.50	—	0.29	—	0.50	—	0.31
29. *P. fusisporus*	—	0.14	—	—	—	—	—	—	—	—
30. *Penicillium charlesii*	0.22	0.14	—	—	—	—	—	—	—	—
31. *P. duclauxi*	—	—	0.50	5.00	—	—	7.50	—	—	—
32. *P. varians*	0.14	0.27	—	—	—	—	0.25	—	—	—
33. *P. verruculosum*	0.44	—	0.33	—	—	—	1.75	2.39	1.75	0.90
34. *P. vineceum*	—	0.07	—	—	—	—	—	—	—	—
35. *Pestalotiopsis versicolor*	—	—	—	1.33	—	—	—	—	—	—
36. *Pullularia pullulans*	0.10	0.25	—	—	—	—	—	—	—	—
37. *Rhizoctonia bataticola*	0.20	0.14	—	—	—	—	—	—	—	—
38. *R. solani*	—	—	0.25	—	—	—	—	—	—	—
39. *Trichoderma lignorum*	4.56	0.19	1.75	—	0.25	1.16	0.27	—	0.50	0.31
40. Mycelia sterilia (Sterile mycelium)	0.32	0.05	—	—	—	0.41	—	—	0.50	—

R — rhizosphere, S — soil.

of 15 cm in sterile Petri dishes. Observations for rhizoplane fungi were made by the serial root washing technique of HARLEY—WAID (1955). The data was subjected to the two-way analysis of variance to test significance.

Quantitative effects. Use of commercial fertilizers increased the fungal population in the rhizosphere of groundnut throughout the growth period. The increase was in the order of N > P > K > NPK. Higher counts of fungi were recorded in the rhizosphere at the time of flowering and the maturation period. In soil there was a highly significant effect ($P < 0.01$ per cent F. 6.882) on the mycofloral population due to use of fertilizers. The highest rhizosphere effects (R/S ratio) were obtained at various periods of growth with different fertilizer treatments (Table 1).

Qualitative effects. A total of 48 species of fungi belonging to 22 genera were recorded during the entire experiment. The number of species was reduced in both the rhizosphere and soil due to the treatment of the soil with fertilizers (rhizosphere control—30, N and P—17, K and NPK—18; soil control—29, N—20, P—14, K—17, NPK—16 species).

Effect on the distribution of taxonomic groups. 14 species of aspergilli, 6 species of penicilli, 14 species of *Deuteromycetes*, 4 species of fusaria, 7 species of *Phycomycetes* and 3 species of *Ascomycetes* were isolated (Table 2). It was observed that aspergilli were dominant both in the rhizosphere and soil of groundnut grown in the plots treated for K and NPK while penicilli for N and P. All the groups of fungi except *Deuteromycetes* were increased considerably in both the rhizosphere and soil with the increase of N, P, K and NPK in soil. The group of *Ascomycetes* was increased only in the rhizosphere of NPK treated plots.

Effect on the distribution of dominant fungal species. Species that showed a population more than five thousand per gram of rhizosphere soil were considered to be dominant species (a population of 5000 represented about 5 per cent of the highest number recorded at a time of estimation). Of the 8 species of dominant fungi from the rhizosphere and soil, some were increased in their counts by the use of fertilizers whereas others were unaffected, reduced or apparently absent (Table 3). The following changes were noted according to the response of the species to fertilizers.

1. The species increased in their counts with the use of N, P, K and NPK providing fertilizers in both the rhizosphere and soil: *Penicillium funiculosum* (str. 1), *Rhizopus stolonifer*, *Aspergillus fumigatus* (str. 1), *A. flavus*, *Fusarium semitectum*.

2. The species decreased in its counts with the use of N, P, K and NPK providing fertilizers in both the rhizosphere and soil: *A. carbonarius*.

3. The species increased in its counts with the increase N, P, K and NPK in the rhizosphere only: *F. oxysporum*.

4. *A. aculeatus* was increased in the rhizosphere of groundnut grown in the plots treated for N and K.

Effect on the distribution of rare fungal species. Amongst the rare fungi *A. niger* and *A. terreus* were more or less unaffected, *Trichoderma lognorum* was reduced, while *Chaetomium longirostrae*, *Cladosporium oxysporum*, *Curvularia lunata*, *Chaetomella raphigera*, *F. solani*, *Mortierella* sp., *Phytophthora marathwadensis*, *P. charlesii* and *Rhizoctonia bataticola* were not isolated from the rhizosphere or soil of plants raised in fertilized soil (Table 4).

Effect of the rhizoplane mycoflora. A total of 15 species of fungi were isolated from the rhizoplane of groundnut raised in plots treated with fertilizers. Of these, 9 were isolated from non-fertilized control, 11 from N, 9 from P, 8 from K and 6 from NPK provided plots. *Rhizopus stolonifer*, *A. carbonarius*, *A. fumigatus* (str. 1), *A. niger*, *F. oxysporum* and *F. semitectum* were present on the rhizoplane of the plants raised in plots treated with all fertilizers, while *A. terreus* and *F. moniliformae* were present only in plots treated with N providing fertilizer. *Trichoderma lignorum* was present on the rhizoplane of plants raised in non-fertilized control plots and plots fertilized for N only.

Amendments to soil with commercial fertilizer resulted in many changes in the rhizosphere mycoflora of groundnut. Urea and superphosphate increased the rhizosphere effect but not muriate of potash or NPK mixture. KATZNELSON (1965) stated that the effects of soil amendments on microflora are unpredictable. Due to the rhizosphere effect the microbial population may increase (DAVEY—PAPAVIZAS 1960, MISHRA 1967) or decrease in number (CLARK 1939) or may be unaffected (VOROSHILOVA 1956). Increased rhizosphere effect in amended soil may be due to greater vigour of the plants resulting in more secretions from the roots.

A decrease in the number of individual species isolated was found in the rhizosphere and soil due to the fertilizers although the total population of fungi was higher. It is probable that there is preferential stimulation of certain fungi in the rhizosphere while certain others might be suppressed. Selective stimulation of certain fungi in the rhizosphere had been reported by DAVEY—PAPAVIZAS (1960). Populations of individual fungal species were markedly influenced by the treatments given to soil or to the groundnut plants. Increase or decrease or even apparent elimination of certain species was recorded. *P. funiculosum* (str. 1), *R. stolonifer*, *A. flavus*, *A. fumigatus* (str. 1) and *F. semitestum* were increased in their number by the fertilizers in the rhizosphere as well as in the soil while *F. oxysporum* increased only in the rhizosphere. *A. carbonarius* was decreased in its number in all the fertilizer amendments. Both stimulatory and inhibitory effects were noticed by different workers as a result of mineral fertilization of soil (GUILLEMAT—MONTEGUT 1960, JOFFE 1963, MISHRA 1967). It is possible that increased competition is responsible for the reduction of *A. carbonarius*.

The fungi isolated from root surfaces were those normally encountered in the rhizosphere. *A. carbonarius*, *A. niger*, *R. stolonifer* and *F. semitectum* were present in most of the treatments. The other 11 species were recorded in various fertilizer treatments but their occurrence was mostly sporadic. It can be concluded that a study of rhizoplane organism can serve as an indicator of the rhizosphere effect in groundnut. This is in agreement with the opinion originally expressed by CLARK (1949). *Rhizoctonia bataticola* was isolated more frequently only from the rhizoplane of plants grown in the plots treated with urea. The problem of whether this potential plant pathogen contributes to the disease development in plants grown in urea treated plots, needs further investigation.

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SEX EXPRESSION OF THE PLUM VARIETY "BESZTERCEI SZILVA" BY FRUIT REGULATING CHEMICALS

According to SCHUMACHER (1965) plum is one of the species most inclined to alternation among the temperate tree fruits. The researchers try to influence this undesired property by primary (fruit bud differentiation) and secondary (thinning of flower and fruit primordia, stimulation of setting) fruit regulation. Although from a physiological point of view primary regulation seems to be more favourable, the secondary methods still play a more important role.

Unfortunately, during the fruit thinning experiments no sufficient attention is paid in many cases to the after-effects, although the analysis of one-year results (year of the treatment) does not make it possible to point out consequences unfavourable in the long run, e.g. the spontaneity of fruit production does not even decrease after the treatment (!) Large yields must be fought against because they decrease — sometimes to a harmful extent — the function of the sex organs in perennial plants producing repeatedly (LENZ 1970) and once a year, respectively; the effect is shown in the atrophy of the pistils or their increased fertility.

The histological aspects of the plum carpel have been dealt with by many (STERLING 1953, 1964, SCHÄPPI 1951, MELVILLE 1962), while the androecium was studied mainly by HASKELL—DOW (1955); this research was continued by MORRISON (1964) who pointed out that the genetic properties of the plum varieties determined the stamen number — in spite of the modifying effect of the environmental factors. There is a difference in the number of stamina between the diploid and tetraploid varieties.

The generative character of flower buds in plum is of varying measure. The degree of regression of the hypsophyll shows the generative effect. We have recent results corresponding to the data of pistil, stamina, twin flowers and rudimental organs (HASSIB 1966). There is a correlation demonstrable by the varieties "Besztercei szilva" and "Jeruzsálemi kék" between shoot and flower organization (SURÁNYI 1971a), and important practical conclusions can be drawn from the teratomes (SURÁNYI 1972).

TÓTH (1967) studied the fertilization conditions of 52 plum varieties. Knowing his results we tried to supply data giving evidence of self-fertility from a physiological aspect,

on the basis of the flower structure. The quotients (stamen number per unit pistil length) of the *Prunoideae* species significantly differ (SURÁNYI 1971b).

The negative correlation of the gynoecium and androecium remarkably differs in the case of self-fertile and self-sterile varieties, namely, in self-fertile *Prunus* varieties changes in the pistil size modify the stamen number to a greater extent than in the case of self-sterile varieties. In a mathematical sense, the regression coefficient (*b*) of the self-fertile varieties is more than sixfold of that of the self-sterile ones (SURÁNYI 1973).

Most of the fruit thinning chemicals are of auxin action, so the effect of fruit regulating treatments on flower organization can be best studied by investigations into the gynoecium. This is important, since it is from rudimental and low function pistils that conclusions on the poor fruit yield can be best drawn, even if the intensity of flowering is high. The calyx → gynoecium → corolla → androecium succession of decreasing "vegetative character" (RESENDE 1967) supports our theory. Our present paper contributes to the experimental evidences of this supposition.

Treatments with 36 and 72 ppm Pomonit (potassium salt of alpha-naphthyl acetic acid), 60 and 120 ppm Amid-thin (amide of alpha-naphthyl acetic acid), 1000 and 2000 ppm Sevin (1-naphtyl-N-mehthyl carbamate), as well as control treatments were performed in 1971 with sixteen years old "Besztercei szilva" plum trees. On the day of the treatment (14 May) and a month later the fruit primordia on two shoots of each tree were counted; replication was three per treatment. Fruit yield per tree in the year of the treatment and in the next season was also recorded.

On two days (21 and 28 April) in 1972 the trees were treated with 36, 54 and 72 ppm concentrations of Pomonit, with eight replications per treatment. Similarly to the previous year's experiment the one month fruit setting percentage as well as the fruit yields of the current and subsequent year were measured.

In connection with the experiments some ecological factors are worth being mentioned too. In 1971 the maximum temperature was 26.5°C, the minimum 12.0°C, the relative humidity 49.0 per cent; the meteorological data of the pentades preceding and following the treatment did not essentially deviate from the values on the day of the treatment. The maximum and minimum temperature values of 21.5°C and 14.0°C on 21st April, and 7.0°C on 28th April, respectively, in 1972 show substantially different climatic conditions. Correspondingly, the relative humidity rose to 89.4 per cent on 28th April compared to the 61.4 per cent value of 21st April.

In the years following the treatments — 1972 and 1973 — flower samples consisting of 100 flowers per treatment were collected from the trees of each treatment at the time of full blossoming, according to our former method (SURÁNYI 1971b). The averages of two data per treatment were used in the calculations, so the analysis of variance calculations were carried out with 7×50 factors in both years.

We measured (on 12 April 1972 and 25 April 1973) the length of the pistil, the functional stamina and the staminodia, and from this obtained the total number of stamina. On the day of measuring we counted the isolated flowers on one shoot of each of 3 (1971) and 8 (1972) trees per treatment in order to determine the degree of self-fertility. A month later we repeatedly counted the fruit primordia.

Correlations were found between the pistil size and the number of functional stamina, the pistil length and the phylloid stamina as well as between the quotient and the selfing percentage. The quotient is the number of functional stamina per unit pistil length, which is a specific self-fertility index for the subfamily *Prunoideae*.

Effect of fruit thinning chemicals on the yield of the trees. Demonstrable thinning in 1971 was only attained with higher concentrations of Pomonit and Amid-thin. It is not likely that it was the consequence of the heterogeneity of the stand, since the size and major pheno-

phases of the sixteen years old "Besztercei" trees showed a great homogeneity. There was no unambiguous correlation between the yield amount and the setting percentage, suggesting that one or two shoots per tree did not sufficiently represent the thinning.

In the year following the treatment (it was a year with a spontaneous large yield) the fruit yield of trees treated with Pomonit of 72 ppm was very high. In comparison with 1971 the yield was large in the other treatments too; the lowest degree of alternation, i.e. BBI-index (SCHUMACHER 1965) was shown by the control (3.47 per cent), while Pomonit at 72 ppm resulted in the highest degree of periodicity (60.96 per cent). All this supports our opinion expressed in the introduction that the fruit thinning chemicals and technologies cannot be evaluated on the basis of a single year's results, the observations should be carried on over several years (on after-effects at least in two successive years).

The experiment performed in 1972 resulted in a much better thinning; as a whole the second date proved to be more favourable. Of the treatments performed on 21st April the 54 ppm Pomonit while of those made on 28th April the 36 ppm Pomonit was the most effective. Larger yield in 1973 was only obtained as a consequence of 54 ppm Pomonit applied on 21st April, that is alternation was not unambiguously decreased in this experiment (Table 1).

After-effects of fruit regulators: their role in the flower organization. In some respects our investigations into the flower organs helped in detecting the causes of our inconsequent results. A detailed analysis of the stamen number revealed that in 1972 as an after-effect of Pomonit applied at 72 ppm staminodia occurred more frequently, so the functional stamina were less in the flowers. In accordance with this, on the other hand, the pistil became larger, thus the value of the quotient was lower compared to the control. The opposite response was observed due to treatments with 60 ppm Amid-thin. The self-fertility percentage in each treatment was lower than in the flowers of untreated trees, which is in connection with the intensity of flowering. Owing to an increase in the number of flowers per tree (Pomonit: 2-fold, Amid-thin: 1.5-fold and Sevin: 0.5-fold) the self-fertile capacity decreased (Table 2).

As on the basis of our previous year's results we rightly expected that Pomonit would be effective, we only used this chemical in 1972. The necessity of an after-effect analysis is proved by the second half of Table 2. Namely, an increased thinning in years of large yields does not fail to make its effect felt in the subsequent year: the larger dose of Pomonit applied at both times resulted in stronger, better functioning flowers. In this sense self-fertility was best improved by the 54 ppm Pomonit used on 21st April and the 36 ppm Pomonit applied on 28th April. In the former case it was realized in the per tree fruit yield too. According to our investigations made on 25th April 1973 Pomonit as a synthetic preparation of auxin action was able to influence to a considerable extent the sex correlation (first of all at a concentration of 72 ppm); the gynoecium strengthened at the expense of the androecium. The ensuing change proved to be favourable unlike after the treatments of 1971.

In both cases a very close sex correlation was pointed out between the pistil size and the number of functional stamina. The increase of the pistil size can only be imagined with a simultaneous decrease in the number of functional stamina ($+0.2561$ and $+0.2296$). An acceptable correlation was found between the averages of stamen number per unit pistil length and of self-fertility percentage in 7 treatments of each of the years 1971 and 1972; that is, even with a simple morphological examination, data can be obtained concerning the extent of self-fertility (Table 3 and Fig. 1).

The plum as a fruit species of periodical production requires the decrease of irregular yields. Fortunately, a number of chemicals have been successfully used in decreasing the overabundant setting, but as to their after-effects these chemicals differ from each other. Some important compounds are: alpha-naphthyl acetic acid, 1-naphthyl-N-methyl carbamate and 3-chlorophenoxy acetic acid.

According to WERTHEIM (1965, 1966) the 0.2 per cent solution of Geramid neu (NAd)

Table 1

Effects of fruit-thinning chemicals on fruit setting and yield per tree

Treatment	Fruit setting after a month, %	Yield	
		in the year of treatment	in the subsequent year
		kg/tree	
		1971	
Pomonit 36 ppm	69.5	50*	164.7**
Pomonit 72 ppm	54.7*	72	146.7°
Amid-thin 60 ppm	86.2	36**	97.3
Amid-thin 120 ppm	62.5°	84	105.7
Sevin 1000 ppm	74.3	88	101.0
Sevin 2000 ppm	77.1	80	60.0
Control	89.9	100	96.7
L.S.D. 5%	29.73	41.25	56.32
		1972	
Pomonit 36 ppm, 1	45.2***	153	24.4
Pomonit 54 ppm, 1	46.0***	108°	41.1*
Pomonit 72 ppm, 1	46.0***	117	16.2
Control	71.9	139	19.0
Pomonit 36 ppm, 2	46.2**	101*	18.6
Pomonit 54 ppm, 2	47.4**	127	26.6
Pomonit 72 ppm, 2	46.8**	126	24.2
L.S.D. 5%	15.62	31.45	19.81

Treatments: 14 May 1971: Length of fruits: 4.65 mm
21 April 1972: Length of fruits: 2.68 mm (1)
28 April 1972: Length of fruits: 6.33 mm (2)

° p = 10%
* p = 5%
** p = 1%
*** p = 0.1%

applied at the time of flowering has a good thinning effect, though the susceptibility of the varieties is different. Indian researchers made attempts with 15 types of treatments of which the best results were obtained with the above listed chemicals (SINGH 1961, SINGH—BAJWA 1964, BAJWA—SINGH 1970). BEUTEL (1969) attained favourable results with 3—CP when applied in a dose of 100—150 ppm at the end of flowering. The experiences gained with Sevin are inconsistent; some authors found it ineffective (SLETTEN 1966, WERTHEIM 1965, 1966), but KARDUX (1964) reported on unambiguous intensive thinning. Still the use of Sevin is not recommended, because our several years' unpublished data reveal that it inhibits the next year's flower bud formation. All this is clearly seen in the three years' accumulated fruit yield.

The results of the present publication justify our expectations concerning Pomonit. The yield shows a favourable trend, and the balanced production spares the trees, especially

Table 2

After-effects of fruit-thinning treatments on sexual organs and self-fertility in the plum variety "Besztercei"

Treatment	Stamina, %			Pistil length, mm	Quotient, pc/mm	Self-fertility, %
	Total	Staminodia	Functional			
			1972			
Pomonit 36 ppm	21.60	1.52	20.08	15.28*	1.31	45.2
Pomonit 72 ppm	21.28	2.47°	18.81°	15.50**	1.21**	46.0
Amid-thin 60 ppm	21.80	0.80*	21.00*	15.08	1.39°	40.0
Amid-thin 120 ppm	21.12	2.12	19.00	14.38°	1.32	60.3
Sevin 1000 ppm	21.26	2.17	19.09	14.15*	1.34	46.2
Sevin 2000 ppm	21.13	2.13	19.00	14.61	1.30	47.4
Control	21.40	1.78	19.59	14.77	1.32	46.8
L.S.D. 5%	0.78	0.85	1.08	0.44	0.08	—
			1973			
Pomonit 36 ppm, 1	21.04°	2.16***	18.88***	13.56	1.39***	50.1
Pomonit 54 ppm, 1	20.64*	1.12***	19.52***	13.96	1.40***	53.7
Pomonit 72 ppm, 1	21.48	6.92*	14.56**	14.12°	1.03**	41.9
Control	22.24	5.96	16.28	13.80	1.18	42.7
Pomonit 36 ppm, 2	20.60*	2.08***	18.56***	13.84	1.34**	52.8
Pomonit 54 ppm, 2	20.80*	2.80***	18.00**	13.32°	1.35**	39.9
Pomonit 72 ppm, 2	21.60	6.64°	14.96*	14.12°	1.05**	37.4
L.S.D. 5%	1.31	0.96	1.22	0.31	0.09	—

° p = 10%
* p = 5%
** p = 1%
*** p = 0.1%

Table 3

Results of correlation calculations from after-effects of fruit-thinning treatments

Relationship between	Year	r-value	p %
Pistil length and functional stamina	1972	−0.3081	1
	1973	−0.2344	2
Pistil length and staminodia	1972	+0.2561	2
	1973	+0.2296	5
Quotient and self-fertility (see Fig. 2)	1972−1973	+0.5020	10

the older ones. In spite of this the actual results sometimes do not meet our expectations. This may have two causes: 1. treatment was carried out in a year of low production (and upset the production balance so much the more); 2. as an effect of the treatments the intensive flower formation compensates the setting.

In an earlier paper we already mentioned the possibility of preventing the failure of setting in fruit varieties of low fertility by applying chemical treatment at the time of fruit bud differentiation (SURÁNYI 1973). The same holds true in the case of high fertility self-fertile varieties too, as after years of large and small yield, respectively, we can never obtain the same setting percentage.

Apart from their efficiency the chemicals of auxin action are favourable because they are able to act directly on the sexual zones, namely on the gynoecium. After all, it is not so important to attain intensive flowering in the year following the treatment as to increase the fertility of flowers. And from the point of view of fruit growing it is of vital importance that the pistils should be fertile, because the producers are able to eliminate the deficiencies of the stamina by variety combination, but flowers with rudimental pistils exclude even the possibility of fruit setting.

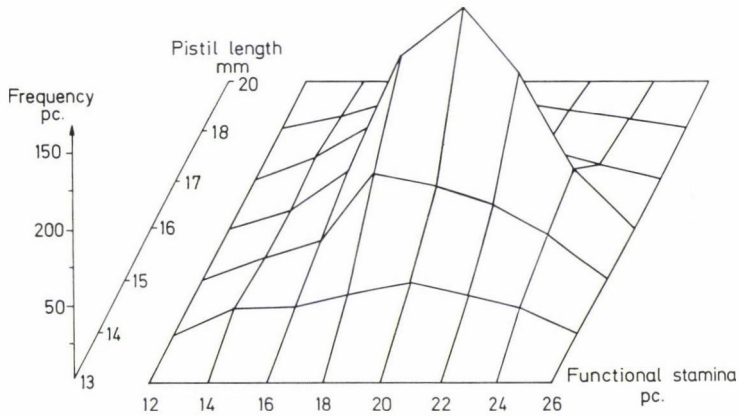

Fig. 1. The pistil length and functional stamina of the plum variety "Besztercei szilva" in a space diagram (n = 700, 1972 and 1973)

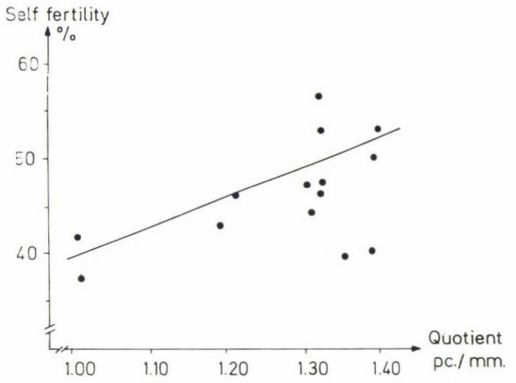

Fig. 2. Relationship between sexual quotient and self-fertility on "Besztercei szilva" trees

With the earlier recognized sex correlation we succeeded in finding the cause of the difference between the results of 1972 and 1973. The potassium salt of alpha-naphthyl acetic acid increased the number of staminodia in both years, at the same time the pistils became larger. On the other hand, the similar results of the two years meant different final results: in 1972 the dominance of the gynoecium was stronger than desired, so the self-fertile capacity decreased; in 1973 a change of the same tendency proved favourable, because the treatments — after an overstrain caused by the previous year's large yield — promoted the development of more viable pistils, and the extent of self-fertility increased.

This may be the way to exercise by chemicals — even if to a limited extent — an effect on sex expression equivalent to the environmental factors (RUHLAND 1967); this means, in fact, the systematic exploitation of the genetically loosely determined sexuality of plants taking the aspects of cultivation and economy into consideration (PORPÁCZY *et al.* 1964)

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RUMINAL VOLATILE FATTY ACID CONCENTRATION IN GROWING LAMBS AS AFFECTED BY THE LEVEL OF DIETARY PROTEIN

Volatile fatty acids (VFA) constitute the major source of energy to the ruminant. Various levels of VFA in the rumen liquor were obtained under the effect of different levels and types of dietary protein. It has been suggested that there is a relationship between the concentration of rumen VFA and the performance of animals consuming different rations (ELLIOTT *et al.* 1965, JUHÁSZ 1965, CLINE *et al.* 1966 and WEISS *et al.* 1967).

This experiment was designed to study the effect of different levels of dietary protein on the total concentration and proportional rumen VFA in growing lambs. Gains in the body weight of lambs have been reported in an earlier work (MAHMOUD 1972).

Animals used previously were used in this experiment under the same nutritional aspects (MAHMOUD 1972). Four groups of Hungarian Merino lambs were fed on four different levels of dietary protein (13.8, 16.5, 19.5 and 23.5%) respectively (MAHMOUD 1972).

Rumen liquor was taken by a polythene forestomach tube (Jarret fistale) for VFA determination. The samples were taken three times through the whole experiment at intervals of 45, 86 and 143 days. Every time the samples were collected before feeding, and 3 and 6 hours after feeding. The method of STOORY—MILLARD (1965) for the determination of steam VFA in rumen liquor was used in the present work using Chrom 3 IKZ (CSSR) gas-chromatography apparatus with flame ionization detector.

Mean concentration of VFA in rumen liquor for the different groups is shown in Table 1. There was a trend for the VFA concentration to decrease by increasing the level of dietary protein. After 86 days' feeding the highest mean concentration (mM/L) was found in the 1st group (70.9) followed by the 2nd one (60.2) and the lowest concentrations were found in the 3rd (55.6) and 4th groups (55.5). It has been reported that the concentration of acetic, propionic, butyric plus higher acids and total acids in the rumen of cows was greatest at the medium level of protein intake compared with the low and high levels. We have confirmed these findings in our experiments on lambs because the differences in VFA concentration between the different groups was found to be significant after 45 days' feeding ($p < 0.01$) and after 86 days' feeding ($p < 0.05$) but the differences were not significant after 143 days' feeding (Table 4).

In this study the molar per cents of the individual acids for the first group at 20 weeks of age were 53.6; 27.9; 15.7; 1.9 and 0.8; while at 25 weeks it was 46.3; 35.7; 14.9; 0.0 and 3.0 for acetic, propionic, butyric, isovaleric and valeric acid respectively (Table 2). It has been stated that at 17 weeks of age this molar per cent was 54.1, 26.7, 16.1, 1.1 and 1.3, respectively. The concentration and molar per cent of ruminal VFA are influenced by the composition and physical form of the diet. The higher levels of propionic acids obtained at the expense of acetic acid were due to the concentrated rations in this experiment.

Table 1

Mean concentration of total volatile fatty acids in rumen liquor for different groups (mM/L)*

Feeding time	Groups			
	1	2	3	4
45 days	52.3±3.18**	50.9±2.57	33.3±0.75	34.8±3.69
86 days	70.9±1.56	60.2±4.21	55.6±4.19	55.5±2.88
143 days	—	70.1±5.82	55.9±8.48	59.5±6.51

* Mean of three animals, average of two determinations 3 and 6 hours after feeding for each animal.
** Standard error.

Table 2

*Mean molar per cent of individual volatile fatty acids in rumen liquor for different groups**

	Feeding time VFA														
	45 days					86 days					143 days				
	C_2	C_3	n-C_4	iso-C_5	n-C_5	C_2	C_3	n-C_4	iso-C_5	n-C_5	C_2	C_3	n-C_4	iso-C_5	n-C_5
Group 1	53.6	27.9	15.7	1.9	0.8	46.3	35.7	14.9	0.0	3.0	—	—	—	—	—
Group 2	47.6	39.3	10.9	0.0	2.3	48.5	35.7	14.2	0.0	3.5	40.0	43.8	14.5	0.0	1.4
Group 3	51.3	32.4	16.3	0.0	0.0	50.4	31.3	13.7	1.6	3.7	47.5	39.3	10.0	1.6	2.4
Group 4	60.2	23.6	15.7	0.6	0.9	52.7	24.9	20.3	0.9	1.6	48.1	32.1	18.8	0.0	1.7

* Mean of three animals, two estimations were determined for each animal, 3 and 6 hours after feeding.

Table 3

*Mean ratio of C_2/C_3 and C_2/C_4 in rumen liquor for different groups**

Feeding time		Groups			
		1	2	3	4
45 days	C_2/C_3	1.98±0.36**	1.24±0.08	1.62±0.14	2.56±0.10
	C_2/C_4	3.75±0.98	4.43±0.17	3.22±0.27	3.99±0.13
86 days	C_2/C_3	1.30±0.04	1.49±0.64	1.67±0.19	2.16±0.08
	C_2/C_4	3.18±0.32	3.45±0.17	3.71±0.14	2.59±0.10
143 days	C_2/C_3	—	0.92±0.02	1.53±0.68	1.55±0.22
	C_2/C_4	—	3.03±0.50	4.72±0.24	2.66±0.31

* Mean of three animals, average of two determinations 3 and 6 hours after feeding for each animal.
** Standard error.

Table 4

Analysis of variance of ruminal VFA data

Feeding time	Source of variation	D.F.	Mean square		
			Total VFA	C_2/C_3	C_2/C_4
45 days	Groups	3	105.54**	0.9469*	0.756
	Error	8	5.35	0.1262	0.813
	Total	11	—	—	—
86 days	Groups	3	55.96*	0.4097	0.680*
	Error	8	11.97	0.0757	0.124
	Total	11	—	—	—
143 days	Groups	3	60.41	0.3826	3.620*
	Error	6	52.89	0.5084	0.410
	Total	9	—	—	—

* $p < 0.05$
** $p < 0.01$

The acetic/propionic acid ratio (C_2/C_3) was found to be lower in those groups which received the lower levels of protein while it was higher in those groups which received the higher levels of protein (Table 3). At 86 days' feeding significant differences in C_2/C_3 were only found ($p<0.01$) between the first and fourth groups and between the second and fourth groups' (Table 4). Higher growth rates were obtained in the first and second groups compared with the fourth group and this means that the higher growth rate coincided with a lower C_2/C_3. Similar results were obtained by ENSOR *et al.* (1959), MATRONE *et al.* (1965) and WEISS *et al.* (1967).

It was found previously (MAHMOUD 1973) that the dry matter digestibility was decreased with increasing nitrogen intake. TOOPS—ELLIOTT (1964) found that organic matter digestibility was inversely related to the proportion of acetic acid. Other authors also indicated that the infusion of acetic acid was associated with a significant reduction in dry matter digestibility. This could be explained as referred by Blaxter (cited by LEWIS 1961) on the bases that the calorimetric efficiency of acetic acid was 59.2%, while of propionic acid was 86.5%. It was generally accepted that propionate is a precursor of sugar. Moreover, MCDONALD (1969) stated that, in ruminants, the utilization of acetate as a source of energy was less efficient than that of glucose.

As shown in Tables 1 and 2 it seems that with higher levels of VFA concentrations higher percentages of propionic acid were also found. These results agree fairly well with those reported by other authors. BALCH—RODLAND (1957) reported that at low ratios of acetic to propionic acid a rapid production of fatty acids coincided with a reduced buffering capacity of the rumen liquor. They suggested that highly acid conditions encourage the proliferation of organisms producing a lower proportion of acetic acid.

A trend for increasing the butyric acid concentration with increasing the level of protein was only found in the fourth group (Table 2). It seems that only in the case of a very high level of protein does the concentration of butyric acid increase and the acetic/butyric acid ratio (C_2/C_4) decrease (Tables 3 and 4).

The isovaleric acid and also traces of isobutyric acid were, generally, found only before feeding but not after feeding. In general, valeric acid was detected in rumen liquor after feeding while only traces were found before feedings (Figs 1 and 2). CLINE *et al.* (1966) found that the addition of isobutyric, isovaleric and valeric acids had a beneficial effect on digestion and nitrogen retention.

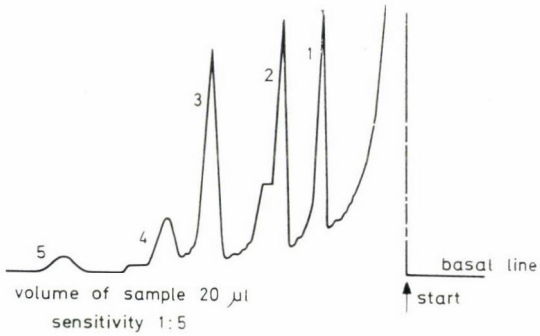

Fig. 1. Chromatogram of VFA in rumen liquor of lamb (No. 25; group 1) before eating (45 days' feeding); 1. acetic acid, 2. propionic acid, 3. *i* and *n* butyric acid, 4. *i* valeric acid, 5. *n* valeric acid

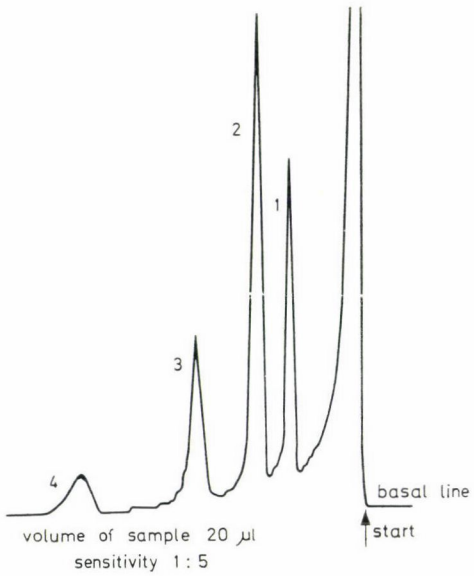

Fig. 2. Chromatogram of VFA in rumen liquor of lamb (No. 25; group 2) 3 hrs after eating (86 days' feeding); 1. acetic acid, 2. propionic acid, 3. *n* butyric acid, 4. *n* valeric acid

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EFFECT OF THE DISTANCE AND PROPORTION OF THE POLLEN DONOR VARIETY ON FRUIT SETTING AND FRUIT YIELD IN PÁNDY SOUR CHERRY

The Pándy sour cherry is a totally self-sterile variety. Its best pollen donors are the late flowering cherry varieties (Germersdorfi óriás, Hedelfingeni óriás, Solymári gömbölyű), certain Cigány sour cherry types and sour cherry varieties. In Hungary the growers most frequently plant the Pándy sour cherry together with the pollen donor cherry variety Germersdorfi óriás. The pollen donor varieties are placed in different ways: scattered, in a row, a block or in a separate plot.

The number, proportion and placing of the pollen donor varieties are determined by their fertility conditions (self-sterile, self-fertile) too.

We studied the effect of the distance and proportion of Germersdorfi óriás as pollen donor on fruit setting and fruit yield in the Pándy sour cherry variety.

We wished to get an answer to the following questions:

— How does the distance of the source of pollen influence the extent of fruit setting?

— Do the proportion, arrangement and distance of the pollen donor variety influence the fruit yield of the Pándy variety?

The investigations were carried out in 1974 at Mindszent. The 30 ha plantation consisted of Pándy sour cherry and Germersdorfi óriás cherry varieties. The area was composed of two oblong plots. One of them was planted with Pándy sour cherry only, on 23 ha, the other with Germersdorfi óriás cherry on 17 ha. The cherry was spaced at 13×8 m, the sour cherry at 8×6 m. The grafts were planted in 1961, the rootstock was Prunus mahaleb; the trees were trained medium high with a leader in the crown.

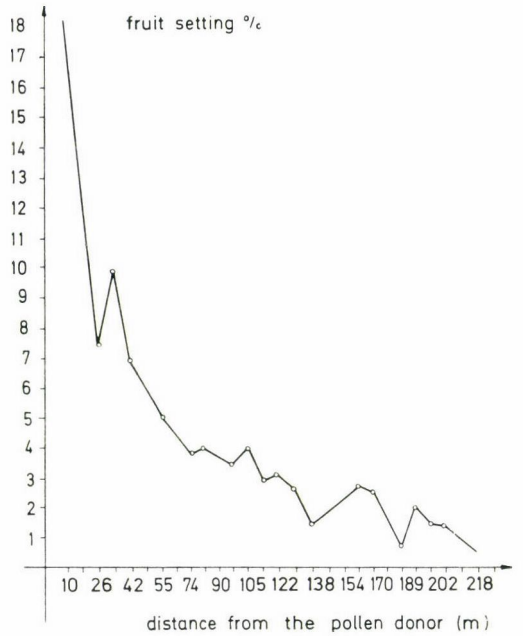

Fig. 1. Effect exerted by the distance of the pollen donor variety on fruit setting in Pándy sour cherry (Mindszent, 1974)

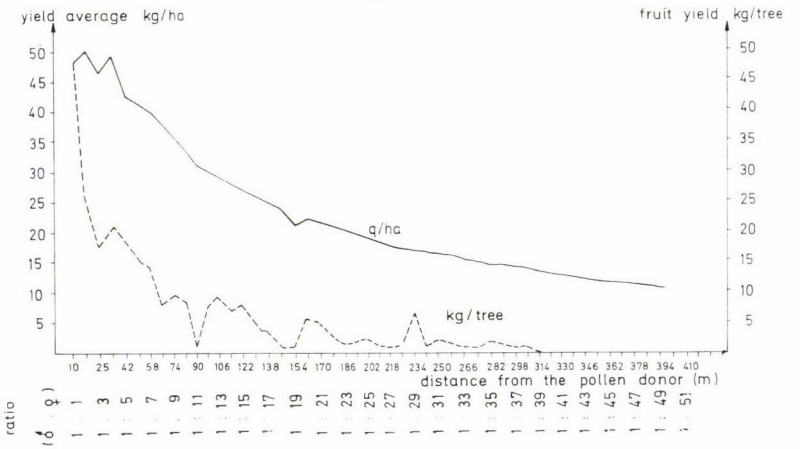

Fig. 2. Effect exerted by the ratio and distance of the cherry variety Germersdorfi óriás on fruit yield in Pándy sour cherry (Mindszent, 1974)

The cherry variety Germersdorfi óriás began to flower on 6th April, mass flowering took place between 10th and 14th April.

In the Pándy sour cherry flowering began on 8th April, and mass blossoming took place between 13th and 17th May. At the time of flowering two families of bees per ha were uniformly distributed over the area.

At the beginning of flowering trees were marked out in each row, starting from the outermost row of the pollen donor variety, for the evaluation of fruit setting originating from free pollination.

Fruit setting was assessed at the medium level of the crown over 1 running metre in all four quarters. Fruit yield per tree was established by weighing.

Fruit setting in the Pándy sour cherry as a function of the distance of the Germersdorfi óriás pollen donor variety is shown in Fig. 1.

Fruit setting in free-pollinated flowers was 18.2 per cent at a distance of 10 m from the row of the Germersdorfi óriás pollen donor variety, and 6.9 per cent in the case of 42 m. With an increasing distance from the pollen donor variety a decrease in the percentage of fruit setting could be pointed out.

The effect of the proportion and distance of the pollen donor variety on the fruit yield per tree (kg/tree) and yield average (q/ha) can be studied in Fig. 2.

Fruit yield per tree in the Pándy sour cherry is the highest (48.5 kg) with a 1 : 1 ratio of the pollen donor variety; in the case of a 1 : 3 ratio the decrease in the fruit yield per tree is very high (18.0 kg/tree). The distance of the source of pollen affected the fruit yield. The fruit yield of the Pándy trees was 48.5 kg at a distance of 10 m from the pollen donor variety, 26.5 kg at 18 m, 20.5 kg at 34 m and 15.0 kg at a distance of 50 m. With an increasing distance from the source of pollen a decrease of the fruit yield per tree could be pointed out; over a distance of 58 m the trees produced practically no fruit.

The pollen donor variety, even if planted in an optimum ratio, increases the fruit yield only when its arrangement and distance from the variety to be pollinated are favourable. The number, ratio, distance and arrangement of the pollen donor varieties have to be planned in such a way as to ensure pollination even under unfavourable conditions (absence of bees, inhibition of pollen transfer).

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COMPARATIVE EFFECTS OF GROWTH SUBSTANCES ON THE GROWTH, FLOWERING AND FRUITING OF TOMATO PLANTS

The effect of growth retardants on the growth, flowering and fruiting of the tomato have earlier been studied in a sporadic manner. In view of the voluminous work on the influence of other growth substances, in different concentrations, on the growth, flowering and fruiting of plants, it was thought desirable to use these substances either singly or in combination in order to study the possible interactions among these substances and the resulting effects on the growth and development of the tomato. The choice of the different combinations of growth substances was as follows: 1. flower formation is either accompanied with or preceded by

stem elongation; 2. auxins, depending on the concentration applied, can promote or inhibit the growth and development of plants; 3. a certain level of gibberellin is necessary for the synthesis of florigens and 4. growth retardants, in general, reduce the vegetative growth, induce flower formation and fruit-setting and interfere with auxin and gibberellin metabolism.

In addition to the critical measurement of the rates of growth, flowering and fruit-setting of the tomato, analyses were carried out of growth substances of the indole type in flower buds and young developing fruits collected from treated plants.

In all experiments, tomato seeds var. "John Moran" were used.

Time course experiments. In experiment I tomato seeds were sown in a mixture of silt and sand (3 : 2) in cans. After 3 weeks the seedlings were transferred to small pots where they were grown for 4 weeks and watered twice during this period with a very dilute solution of ammonium sulphate. Then uniform plants were transferred into soil ridges in the field, the plants being spaced 0.5 meter apart. Ammonium sulphate was used as a fertilizer and the field plot was irrigated according to the usual practice. The plants were sprayed with 0.25% aqueous solution of Roger 40 to avoid infection.

Flower buds were recorded 2 weeks after transplanting to the soil and weekly treatments with growth substances were started by spraying the solutions of the chemicals in 0.5% ethyl alcohol on the entire plant surface. Control plants were sprayed with 0.5% ethanol. Plants were supported with stakes when necessary. The treated plants were divided into 3 groups (Table 1) and were allowed to grow until they were 160 days old. From the initial treatment date until the end of the experiment various measurements of growth, flowering and fruiting of the differently treated plants were recorded.

In experiment II tomato seeds were sown in cans in a soil mixture of Nile silt and coarse sand (3 : 2) and after 2 weeks the seedlings were transferred into 38 cm pots containing silt and sand (3 : 2). Before transplanting 5 g of ammonium sulphate was added to each pot and mixed thoroughly with the soil mixture. The experimental pots were irrigated daily according to the usual practice.

Thinning was made one week after transplanting so that 2 uniform plants per pot were left for experimentation. The plants were sprayed with Roger 40 to avoid infection and at 9 weeks after the sowing date and once weekly afterwards the plants were sprayed with alcoholic solutions of various chemicals (Table 2). Control plants were sprayed with 0.5 per cent ethanol. Certain measurements of growth, flowering and fruiting were made at specific week intervals after initial treatments.

When considered necessary data were statistically analysed. Randomized block experimental designs (with 4—7 replications) were utilized, and an analysis of variance was performed on the data using the F-ratio test. Comparison among means was carried out by calculating the least significant difference (L.S.D.) at the 5 per cent probability level.

In both experiments, for the determination of the growth substances, young flower buds and young fruits (about 10 days old) from the control and treated plants were collected 7 weeks after the start of the treatments. After collection, the samples were rapidly rinsed in distilled water to wash away the dust, shaken free of excess water and stored in a deep freeze ready for extraction.

Estimation of indole auxins. The general procedures for extraction, chromatography and bioassay were essentially those used by YOUNIS—EL-TIGANI (1970). The plant material was disintegrated in a blender in cold redistilled ethanol and then extracted at 0°C for 24 hours using 3 lots of ethanol. The alcohol extract was concentrated at full vacuum at 30°C to a few ml. The plant residue was dried at 100°C for dry weight determination.

Aliquots of the extracts were loaded onto the chromatograms. Auxins were separated in the dark using isopropyl alcohol : ammonia : water (10 : 1 : 1) as a developing solvent (BENNET-CLARK *et al.* 1952).

Table 1

Effect of repeated application of GA_3, NAA and B—995 on mean length of stem (cm) in main axis of John Moran tomato plants grown in field

Treatment and frequency of application	Weeks after initial treatment					
	1	2	3	4	7	14
Group A						
Control	24.3	43.8	67.8	86.5	121.3	176.3
GA_3 100 ppm/2 times	25.8	47.0	68.5	86.3	113.8	148.0
GA_3 100 ppm/5 times	28.0	50.0	84.3	108.0	125.3	169.3
NAA 10 ppm/2 times	23.0	39.0	60.8	79.5	108.5	151.3
NAA 10 ppm/5 times	22.8	40.8	65.5	90.5	121.3	153.3
L.S.D. at 5% level	N.S.*	N.S.	13.26	N.S.	N.S.	N.S.
Group B						
Control	26.7	43.7	64.2	80.8	105.7	153.0
GA_3 10 ppm/3 times	26.5	46.7	70.2	87.8	100.5	140.2
B—995 100 ppm/3 times	26.0	39.0	59.7	74.7	102.2	131.2
L.S.D. at 5% level	N.S.	N.S.	N.S.	19.06	N.S.	32.39
Group C						
Control	27.3	46.4	68.3	85.0	111.4	149.0
B—995 100 ppm/once + GA_3 10 ppm/3 times	27.6	46.4	72.7	87.6	111.7	148.0
L.S.D. at 5% level	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

* N.S. = Not significant.

Duplicate chromatograms were prepared and each was cut into transverse strips, each strip being in width one-tenth of the distance between the start line and the solvent front. Each strip was eluted overnight at 0°C, with 10 ml distilled water.

To assay the activity of extracts, their effect was studied on the straight-growth of *Hordeum* coleoptile segments (YOUNIS—EL-TIGANI 1970). The lengths of sections were measured in red light with a photographic magnifier (×5) and the mean length of 40 sections of the two replicates of each zone strip was calculated. The results are expressed as the final length of the treated sections minus the final length of the water controls, expressed as percentages of the final length of the water controls.

Table 2

Effect of repeated application of growth substances either alone or in combination on mean length of stem (cm) in main axis of John Moran tomato plants grown in pots

Treatment and frequency of application	Weeks after initial treatment					
	1	2	3	4	7	12
Control	42.8	58.8	62.7	69.8	75.3	76.5
GA_3 100 ppm/5 times	45.7	65.5	75.5	85.3	90.3	94.8
NAA 10 ppm/5 times	39.7	48.5	53.2	60.2	75.0	76.8
B—995 100 ppm/3 times	55.7	71.2	78.2	82.8	88.3	88.5
TIBA 10 ppm/5 times	41.8	60.5	63.3	65.7	67.5	70.3
MH 10 ppm/5 times	32.8	42.7	49.3	56.8	74.5	77.0
B—995 100 ppm/once + GA_3 100 ppm/3 times	39.3	60.5	70.2	77.7	85.7	86.0
B—995 10 ppm/once + NAA 10 ppm/3 times	35.2	45.3	47.8	53.8	63.7	67.7
TIBA 10 ppm/twice + GA_3 100 ppm/3 times	30.8	42.7	51.5	60.0	71.8	77.3
MH 10 ppm/twice + GA_3 100 ppm/3 times	23.5	33.5	46.7	61.2	77.3	79.0
L.S.D. at 5% level	3.23	4.45	5.60	6.69	8.02	8.62

A. *Growth responses*

Experiment I. The shoot height was measured weekly for 14 weeks (Table 1). For plants of Group A, twice application of either GA_3* or NAA** had no significant effect on stem length in the first 2 weeks. Further application of GA_3 induced a significant increase in stem length above those of other treatments at 3 weeks after initial treatment, and NAA, on the other hand, did not induce a significant change in stem length. Similar results, though not significant, were obtained at 4 weeks. The stem length of non-treated and treated plants at 7 weeks and at the end of the experiment were not significantly different, but the control plants and those treated 5 times with GA_3 and NAA had the highest values for stem length.

The data in Table 1 for plants of Group B indicate that GA_3 and B—995*** at 10 and 100 ppm respectively did not induce any significant change in the growth of the main axis of treated plants throughout the experiment. At the early periods of growth, however, GA_3 induced a slight extension above the controls and B—995-treated plants. Also by the end of the experiment, B—995 elicited 14% reduction in stem length when compared with controls.

B—995 (100 ppm) followed by GA_3 (10 ppm) elicited no significant effect on stem elongation. This points to the fact that there may have been an interaction between GA_3 and B—995 on stem elongation.

Experiment II. From Table 2 it is apparent that there existed significant differences in stem elongation throughout the experiment as a result of the application of growth substances. Thus, GA_3 induced a significant increase in stem elongation at most times of measurement as

* GA_3 = gibberellic acid
** NAA = naphthalene acetic acid
*** B—995 = N-dimethylaminosuccinamic acid

compared with other treatments except with B—995 and B—995 + GA_3; these two latter treatments induced a stem elongation more or less similar to that of GA_3.

The stem length of NAA-treated plants was significantly lower than that of controls, GA_3- and B—995-treated plants. When compared with other treatments, the increase in stem elongation as affected by NAA application was, in general, not statistically significant.

B—995 was found to increase stem length significantly above most of the other treatments at all stages of growth. This increase due to B—995 treatment is unexpected but if we consider that the initial mean length of the main axis of B—995-treated plants was about 10—15 cm taller than that of the other treated plants, then this increase may not have been solely due to an effect of B—995 on stem elongation.

Except for the first two weeks, the stem length of TIBA* + GA_3-, MH-** and MH + GA_3-treated plants showed similar behaviour throughout the experimental period. The stem elongation of B—995 + NAA-treated plants was the least among the different treatments used. The behaviour of the growth of the main axis of TIBA-treated plants was comparable to that of the controls and NAA-treated plants and lower than of those treated with GA_3, B—995 and B—995 + GA_3. The stem length of TIBA + GA_3, MH and MH + GA_3-treated plants was significantly lower than that of TIBA-treated plants during the first 3 weeks after initial treatment but at later stages the stem length of the former plants caught up that of the latter ones.

B. *Flowering and fruiting responses*

Experiment I. Just before the initial treatment, plants were blooming; one or two flower clusters being recorded at the 9th node of all plants. The number of flower clusters counted at 5 weeks after initial treatment are presented in Table 3.

Within the plants of Group A, no significant differences in the number of flower clusters were observed. However, treatment with GA_3 (100 ppm) five times seemed to have increased the number of flower clusters appreciably above those of controls and other treatments.

The differences in the number of flower clusters on plants of Group B were not significant. But, GA_3 (10 ppm) and B—995 (100 ppm) may have reduced the number of flower clusters below that of the controls. In Group C, the controls and B—995 + GA_3-treated plants showed similar behaviour with respect to the number of flower clusters produced.

For Group A, a five times treatment with 100 ppm GA_3 induced a significantly higher number of flowers per plant than the other treatments but not higher than the controls. For Groups B and C of plants, the differences in the mean number of flowers produced per plant were statistically not significant (Table 3).

It is apparent that spraying GA_3 and NAA 2 or 5 times increased the shedding of flowers of treated plants with varying degrees when compared with the controls. On the other hand, when GA_3 (10 ppm) and B—995 (100 ppm) were applied to the second group of plants, shedding of flowers was reduced and B—995 showed a better result than GA_3. The combination of B—995 with GA_3 increased, but slightly, the rate of flower shedding above that of the controls (Table 3).

Data for the time from seeding to fruiting of the variously treated plants are given in Table 3. For plants of Group A, treatment with GA_3 and NAA induced earlier fruiting and chemicals were most effective when sprayed 5 and 2 times respectively.

* TIBA = 2,3,5-triiodobenzoic acid
** MH = maleic hydrazide

Table 3

Effect of repeated application of GA_3, NAA and B—995 on flowering and fruiting of John Moran tomato plants grown in field

Treatment	Mean No. of flower clusters/ plant	Mean total No. of flowers/ plant	Flowers shed, per cent of total	Time from seeding to fruiting (days)	Mean total No. of fruits/plant
Group A					
Control	15.0	236.8	31.4	114.8	7.5
GA_3 100 ppm/2 times	12.5	160.8	50.5	109.3	4.0
GA_3 100 ppm/5 times	23.3	247.5	36.6	98.0	3.0
NAA 10 ppm/2 times	17.8	174.8	47.8	104.4	14.0
NAA 10 ppm/5 times	17.5	132.5	55.7	110.6	6.8
L.S.D. at 5% level	N.S.	37.45	—	—	6.10
Group B					
Control	22.7	198.0	45.6	111.3	8.3
GA_3 10 ppm/3 times	16.7	217.2	38.9	113.0	3.7
B—995 100 ppm/3 times	11.5	177.8	33.8	101.0	2.2
L.S.D. at 5% level	12.50	N.S.	—	—	N.S.
Group C					
Control	14.6	174.0	44.8	111.3	4.7
B—995 100 ppm/once + GA_3 10 ppm/3 times	16.1	209.0	50.7	107.5	3.7
L.S.D. at 5% level	N.S.	N.S.	—	—	N.S.

Fruit-setting has been markedly enhanced in the plants treated with B—995 in Group B, but spraying GA_3 at 10 ppm 3 times was ineffective as compared with the controls. In Group C, treatment of plants with B—995 + GA_3 slightly induced earlier fruiting. The mean number of fruits of all treated plants, counted at the conclusion of the experiment, are shown in Table 3. Within the first group, NAA (10 ppm) when applied twice to tomato plants increased fruit-setting significantly above the controls and the other treated plants. A slight reduction in the number of fruits per plant was observed in GA_3-treated plants when compared with the controls and plants treated 5 times with 10 ppm of NAA. A three times application of GA_3 at 10 ppm and B—995 at 100 ppm might have reduced the number of fruits per plant below that of the controls although statistical analysis showed that the variations between the different plants were not significant. A similar pattern of changes in the number of fruits was observed in the control and B—995 + GA_3-treated plants.

Table 4

Effect of repeated application of growth substances either alone or in combination on flowering and fruiting of John Moran tomato plants grown in pots

Treatment and frequency of application	Mean No. of flower clusters/ plant	Mean total number of flowers/ plant	Flowers shed, per cent of total	Mean total number of fruits/plant
Control	6.7	39.0	82.5	2.3
GA_3 100 ppm/5 times	3.2	23.3	90.0	0.7
NAA 10 ppm/5 times	6.7	55.7	52.7	1.2
B—995 100 ppm/3 times	8.3	39.8	79.9	5.7
TIBA 10 ppm/5 times	5.0	39.2	75.7	2.0
MH 10 ppm/5 times	5.2	40.0	59.2	3.2
B—995 100 ppm/once + GA_3 100 ppm/3 times	5.2	35.8	64.7	3.5
B—995 100 ppm/once + NAA 10 ppm/3 times	5.2	40.8	48.2	3.7
TIBA 10 ppm/twice + GA_3 100 ppm/3 times	3.8	41.2	50.2	1.8
MH 10 ppm/twice + GA_3 100 ppm/3 times	4.7	30.7	52.7	1.7
L.S.D. at 5% level	1.36	N.S.	—	1.30

Amongst the different treatments used in this experiment GA_3, sprayed alone for 5 times, induced the formation of parthenocarpic fruits; about 60% of the total number of fruits being parthenocarpic. Also, the fruits produced by GA_3-treated plants, particularly the parthenocarpic ones, were inferior in size to those developed by the controls, the NAA- and B—995-treated plants.

Experiment II. The number of flower clusters was counted 5 weeks after initial treatment and the data obtained are shown in Table 4. Thus, a 5 times application of GA_3 at 100 ppm induced a great reduction in the number of flower clusters, a result which was repeated when GA_3 was combined with TIBA. Within the group of plants treated with TIBA, B—995 in combination with either GA_3 or NAA and MH alone or followed by GA_3, the changes in the number of flower clusters were insignificant. Control, NAA- and B—995-treated plants had the highest number of flower clusters and it is apparent also that the flower clusters on B—995-treated plants were significantly higher than those produced by all treated plants in this experiment. However, there were no significant differences recorded in the total number of flowers produced per plant.

The results in Table 4 show that the number of flowers shed per GA_3-treated plants was approximately 90 per cent of the total number of flowers produced throughout the experimental period, a value which was higher than that of the controls. All the other compounds reduced the percentage values for flower shedding.

Table 4 shows the total number of developing and mature fruits counted at the end of the experiment. B—995 (100 ppm) applied 3 times increased the fruit yield significantly over that of the controls and all treated plants. GA_3 and NAA when applied separately markedly reduced the total number of fruits, but when either of these 2 chemicals was combined with B—995, a marked increase in fruit-set was recorded. No significant differences were observed within the controls and the plants treated with other growth substances.

C. *Growth substances in flower buds and young developing fruits*

Young flower buds and young fruits (about 10 days old) from the control and treated plants of the 2 experiments were collected for extraction 7 weeks after the start of the treatments. The changes in the activity of indole auxins are illustrated in Figs 1—4. In these figures the horizontal line indicates the water cntrol above and below which the growth-promoting and growth-inhibiting substances are illustrated respectively.

The activity in extracts from flower buds of untreated plants showed only small amounts of growth-promoting substances at R_F 0.0 to 0.5 and relatively higher amounts of growth-inhibiting substances at the higher R_F values (Fig. 1a). GA_3 at 10 and 100 ppm increased the growth-promoting substances in the flower buds of treated plants (Figs 1b, c and d). As in GA_3-treated plants, NAA increased the growth-promoting substances proportionately with the number of applications (Figs 1e and f). When NAA was applied with B—995, all the chromatogram strips showed growth-promoting activity except at R_F 0.4 to 0.5 where an inhibition was detected (Fig. 1g).

The extracts of flower buds from B—995-treated plants exhibited growth-inhibiting substances at R_F 0.4 to 0.7 and 0.9 to 1.0. At the other regions appreciable growth-promoting substances were apparent (Fig. 2a). The patterns of changes in the growth-regulating substances of flower buds from plants treated with B—995 in combination with GA_3 at 100 (experiment II) and 10 ppm (experiment I) respectively are nearly similar (Figs 2b and c).

When compared with the control flower bud extracts, it seems that TIBA increased the growth-promoting substances (Fig. 2d). On the other hand, with TIBA followed by GA_3, the flower bud extracts showed appreciable amounts of growth-promoting substances at all R_F values (Fig. 2e). It is also interesting to mention that in Fig. 2d the greatest inhibition was observed at R_F 0.4 to 0.5 whereas, as shown in Fig. 2e, this growth-inhibiting zone had disappeared and even might have been replaced by a growth-promoting substance as a result of the combination of TIBA with GA_3.

MH treatment induced the presence of appreciable amounts of growth-inhibiting substances at R_F 0.0 to 0.6 and at higher R_F values growth-regulating substances were hardly detected (Fig. 2f). However, when MH was followed by GA_3 application, appreciable growth-promoting substances appeared at R_F 0.0 to 0.3 and at R_F 0.6 to 0.9 (Fig. 2g). At other R_F values growth-inhibiting substances were detected.

In the case of young fruits, the results obtained are recorded in histograms (Figs 3 and 4). Extracts obtained from fruits of untreated plants showed a high inhibition zone at R_F 0.0 to 1.0 and at higher R_F values, zones of growth-promoting activity were revealed (Fig. 3a). In Figs 3b, c and d it is clear that at 10 and 100 ppm, application of GA_3 induced marked increments in the growth-promoting activity as well as the appearance of slight amounts, if any, of growth-inhibiting substances. But the growth-inhibiting substance detected at R_F 0.0 to 0.1 in control tomatoes was persistent in fruit extracts from plants treated twice with GA_3 at 100 ppm and plants treated 3 times with GA_3 at 10 ppm (Figs 3b and d).

It is apparent that NAA whether applied twice or 6 times has increased the substances of growth-promoting activity when compared with the control (Figs 3a, e and f). Compared with plants treated with NAA alone, application of B—995 followed by NAA induced the disappearance of growth-inhibitors at R_F values higher than 0.1 and further increased the growth-promoting activity in the respective young fruit extracts (Fig. 3g). In the histograms (Figs 3e, f and g) a growth-inhibiting substance appeared at R_F 0.0 to 0.1 and this was lower in activity when compared with that revealed by the control samples (Fig. 3a).

In case of B—995-treated plants, the young tomato fruit extracts showed, as in the controls, a growth-inhibiting substance at R_F 0.0 to 0.1 and an indication of a further inhibitor at R_F 0.9 to 1.0. At other R_F values substances of growth-promoting activity were detected

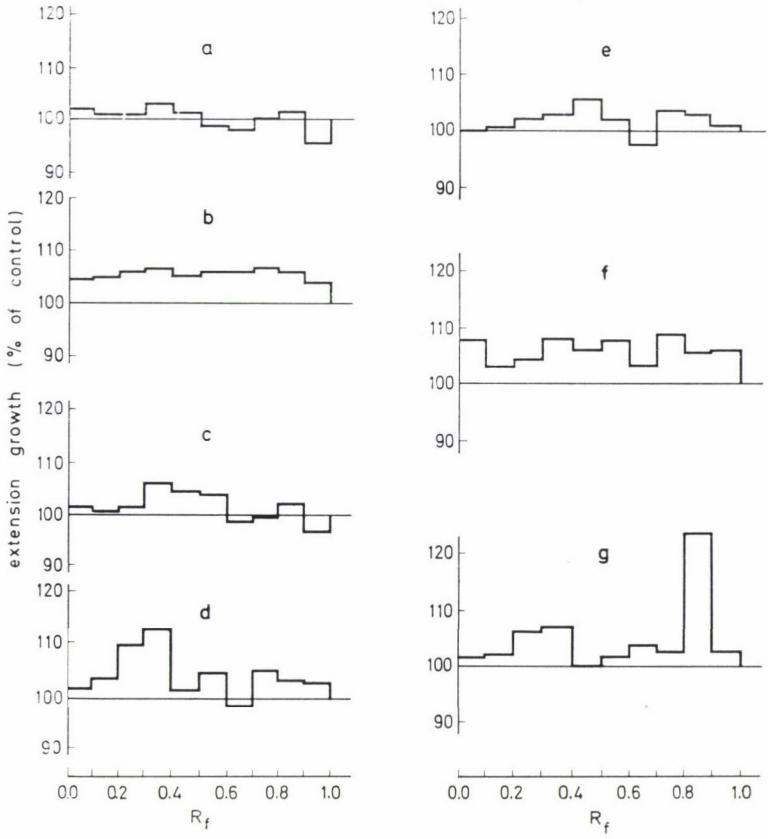

Fig. 1. Histograms showing activities in the *Hordeum* coleoptile test of chromatograms of extracts of flower buds from a = control pot plants; b = field plants sprayed 2 times with GA_3 at 100 ppm; c = pot plants sprayed 5 times with GA_3 at 100 ppm; d = fields plants sprayed 3 times with GA_3 at 10 ppm; e = field plants sprayed 2 times with NAA at 10 ppm; f = pot plants sprayed 5 times with NAA at 10 ppm; g = pot plant sprayed once with B—995 at 100 ppm, followed by NAA at 10 ppm sprayed 3 times. Each chromatogram was strip-loaded with amounts of extract equivalent to 200 mg dry weight of flower buds

(Fig. 4a). Compared with the controls, the GA_3- and B—995-treated plants, spraying with B—995 followed by GA_3 at 100 and 10 ppm caused the disappearance of the growth-inhibiting substances either partially or completely and showed marked amounts of growth-promoting substances (Figs 4b and c).

Young tomatoes from plants sprayed with TIBA either alone or in combination with GA_3 showed a growth-inhibiting substance at R_F 0.0 to 0.1. At the other R_F values growth-promoting activity was detected; the activity being greater in samples treated with TIBA + GA_3 than in samples treated with TIBA alone (Figs 4d and e).

In extracts of fruits from MH-treated plants, there appeared a marked growth-inhibiting substance and low amounts of growth-promoting substances. In the fruit extracts of MH + GA_3-treated plants marked growth-inhibiting substances appeared at all regions of the chromatograms.

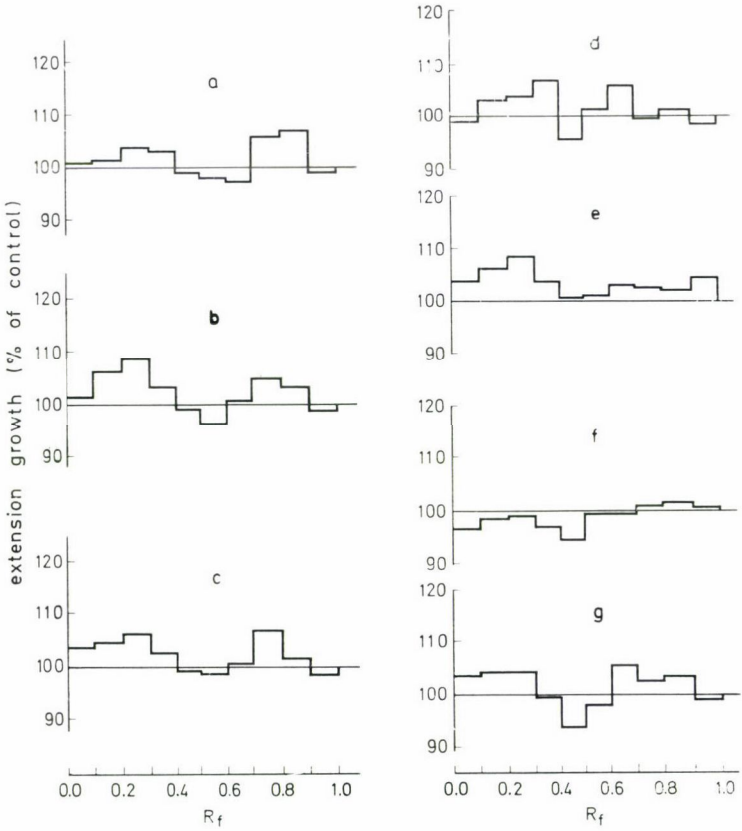

Fig. 2. Histograms showing activities in the *Hordeum* coleoptile test of chromatograms of extracts of flower buds from a = pot plants sprayed 3 times with B—995 at 100 ppm; b = pot plants sprayed once with B—995 at 100 ppm, followed by GA_3 at 100 ppm sprayed 3 times; c = field plants sprayed once with B—995 at 100 ppm, followed by GA_3 at 10 ppm sprayed 3 times; d = pot plants sprayed 5 times with TIBA at 10 ppm; e = pot plants sprayed twice with TIBA at 10 ppm, followed by GA_3 at 100 ppm sprayed 3 times; f = pot plants sprayed 5 times with MH at 10 ppm; g = pot plants sprayed twice with MH at 10 ppm, followed by GA_3 at 100 ppm sprayed 3 times. Each chromatogram was strip-loaded with amounts of extract equivalent to 200 mg dry weight of flower buds

GA_3 was used throughout this investigation at 10 and 100 ppm. At the low concentration, it had no significant effect on stem length. When used at 100 ppm, in general, GA_3 increased stem length significantly. As the number of applications was increased growth rate increased and was maintained for a longer period. However, there was decreasing responsiveness to the chemical with the lapse of time particularly after termination of the weekly treatments. This stimulating effect on shoot length is one of the most characteristic effects of GA_3 on the tomato as well as on all other plants investigated by a great number of authors (Brian—Hemming 1955, Brian *et al.* 1959, Younis—El-Tigani 1970, Foda *et al.* 1970).

B—995 reduced the stem height significantly in most cases. However, in some cases, the B—995-retarding effect was masked as plants developed with the lapse of time. In support of these observations, Picard (1967) reported that at 350γ, B—995 delayed the onset of stem growth, the delay increasing with increasing amounts of application.

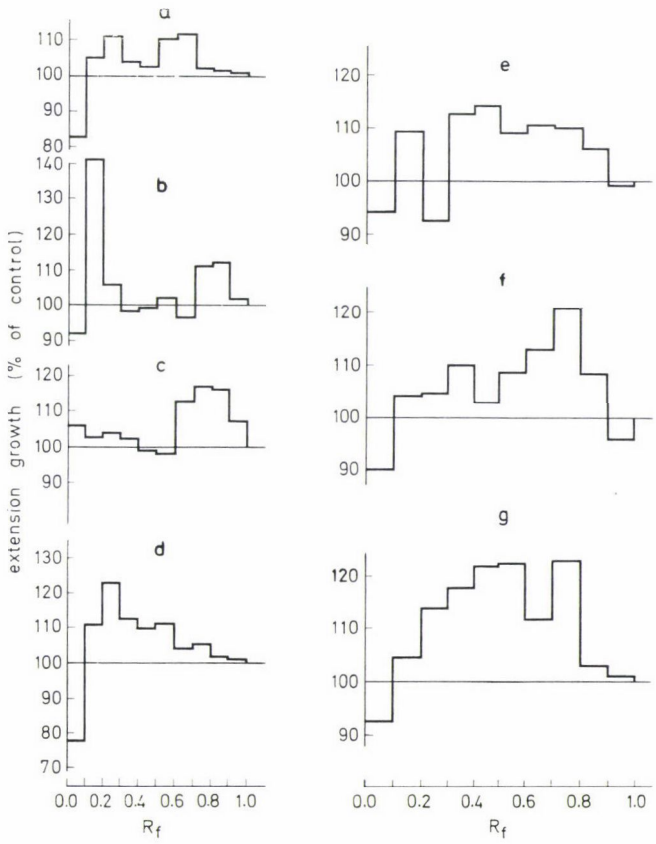

Fig. 3. Histograms showing activities in the *Hordeum* coleoptile test of chromatograms of extracts of young fruits from a = control pot plants; b = field plants sprayed 2 times with GA_3 at 100 ppm; c = pot plants sprayed 5 times with GA_3 at 10 ppm; de = field plants sprayed 2 times with NAA at 10 ppm; f = pot plants sprayed 5 times with NAA at 10 ppm; g = pot plants sprayed once with B—995 at 100 ppm, followed by NAA at 10 ppm sprayed 3 times. Each chromatogram was strip-loaded with amounts of extract equivalent to 250 mg dry weight of young fruits

We should point out that the masked response with the progress of time was, in general, dependent upon the concentration used and the frequency of application. Thus CATHEY (1964) stated that for a marked prolonged reduction of growth, high concentrations of B—995 are required. However, this does not exclude the possibility of B—995 being translocated to non-active regions of growth (ZEEVAART 1966, YOUNIS—ELNUR 1970). Had translocation of B—995 been operative in tomato plants, the growth retarding changes in the apical bud, which were possibly increased by B—995 particularly at the time of treatment, would have been decreased with the progress of time.

It was possible for GA_3 at 100 ppm to counteract the growth-retarding effects of 100 ppm of B—995 (Table 2). In support of this observation, ZEEVART (1966), MOORE (1967), PICARD (1967) and YOUNIS—EL-TIGANI (1970) found that GA_3 was capable of reversing the inhibitory effects of B—995 on different plant tissues and they suggested that B—995 inhibits gibbe-

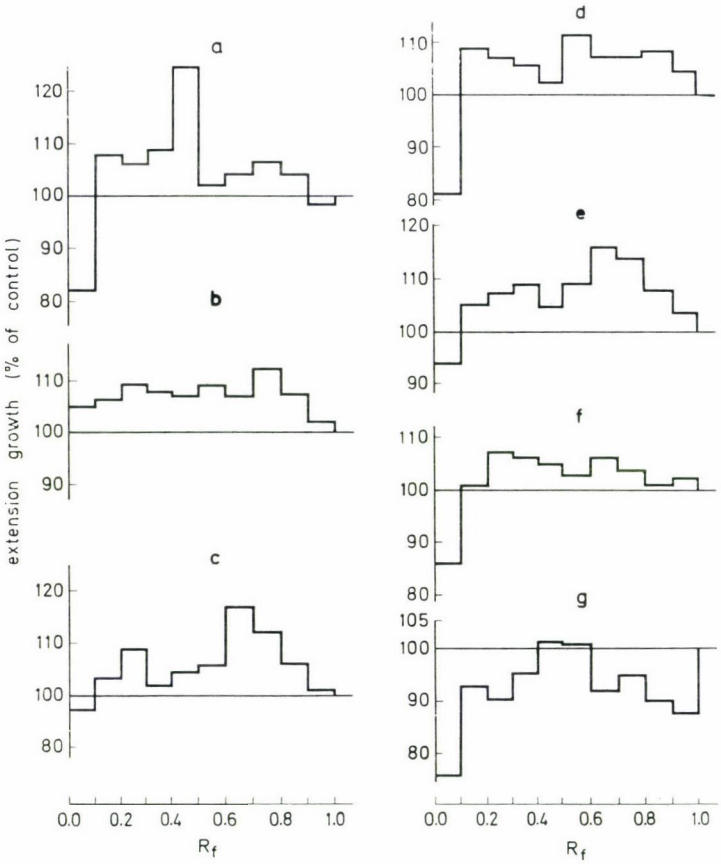

Fig. 4. Histograms showing activities in the *Hordeum* coleoptile test of chromatograms of extracts of young fruits from a = pot plants sprayed 3 times with B—995 at 100 ppm; b = pot plants sprayed once with B—995 at 100 ppm, followed by GA_3 at 100 ppm sprayed 3 times; c = field plants sprayed once with B—995 at 100 ppm, followed by GA_3 at 10 ppm sprayed 3 times; d = pot plants sprayed 5 times with TIBA at 10 ppm; e = plot plants sprayed twice with TIBA at 10 ppm, followed by GA_3 at 100 ppm sprayed 3 times; f = pot plants sprayed 5 times with MH at 10 ppm; g = pot plants sprayed twice with MH at 10 ppm, followed by GA_3 at 100 ppm sprayed 3 times. Each chromatogram was strip-loaded with amounts of extract equivalent to 250 mg dry weight of young fruits

rellin biosynthesis. Thus, YOUNIS—EL-TIGANI (1970) reported a reduction in the gibberellin content of tomato plants treated with B—995.

NAA slightly reduced the stem height and MH sprayed either alone or followed by GA_3 (Table 2) inhibited shoot growth during the early stages of development and with the lapse of time the growth of plants eventually returned to that of untreated plants. In this connection BRIAN—HEMMING (1957) and BUKOVAC—WITTWER (1956) reported a partial counteraction of the growth-inhibiting effects of MH by gibberellins. Also, EL-TIGANI (1969) found that simultaneous application of MH and GA_3 increased the stem height significantly at all stages of growth. Thus, EL-TIGANI concluded that GA_3 can completely prevent the inhibiting action of MH if applied simultaneously with the latter.

TIBA alone and combined with GA_3 did not affect stem length significantly. This result does not agree with that of GALSTON (1947) who reported that TIBA reduced the plant height in soybeans. Thus, it seems that the effect of TIBA on vegetative growth is a function of the concentration of the chemical (LEOPOLD 1955).

In experiment I, GA_3 proved to be the most effective when applied at 100 ppm 5 times. It increased the number of flower clusters, the total number of flowers and did not affect flower shedding when compared with the control. Earlier fruiting was induced than in the control, but the total number of fruits was reduced. A lower concentration and less frequency of application of GA_3 were less effective in the above respects.

Two times spraying of NAA at 10 ppm was found more effective than 5 times. A lower number and higher shedding of flowers than the control were observed. Earlier fruiting and a significant increase in the total number of fruits were also obtained. B—995 either alone or in combination with GA_3 was found inferior in flowering and fruiting responses to NAA and GA_3.

The induction of parthenocarpic fruits was most characteristic of GA_3 and this is in accord with the results of RAPPAPORT (1957) and WITTWER *et al.* (1957). Fruits produced were inferior in size to those developed by control and other treatments as reported by WITTWER—BUKOVAC (1958).

Amongst the different treatments used in experiment II, GA_3 and TIBA + GA_3 reduced, whereas B—995 significantly increased the number of flower clusters. However, no significant differences in the total number of flowers were recorded. Certain treatments e.g. TIBA + GA_3 and MH + GA_3 showed the most promising results in the reduction of flower shedding, unlike GA_3 which increased it.

Also B—995 increased the fruit-set significantly. GA_3 and NAA, when applied separately, highly reduced the total number of fruits. When both chemicals were combined with B—995 a marked increase was observed. TIBA did not affect the yield significantly.

The effect of B—995 on flowering and fruiting seems to be disputed. However, evidence is more in favour of the fact that B—995 treatment, at appropriate concentrations, induces earlier flowering and fruiting accompanied with higher yield (STUART 1961, WITTWER—TOLBERT 1960, YOUNIS—ELNUR 1970). The results of the present investigation lend a support to the increased flowering and yield by B—995.

RAPPAPORT—SINGH (1961) stated that with respect to flowering and fruiting, the effect of gibberellin on plants is not universal. However, in most cases, administration of GA_3 to plants was found to accelerate flowering and fruiting responses.

There are many reports in the literature concerning the effect of externally applied auxin-type compounds including NAA, TIBA and MH on flowering and yield in tomato and other plants (HITCHCOCK—ZIMMERMAN 1935, THIMANN—LANE 1938, STIER—DU BUY 1938, TANG—LOO 1940, COOPER 1942, FISHER—LOOMIS 1954, WITTWER—BUKOVAC 1958). Some of these authors also pointed out that combination of some auxins with GA_3 resulted in better flowering and fruiting responses.

Growth substances seem to be involved in the regulation of many different growth processes including flowering and fruiting. LANG (1961) stated that the growth of the plant may depend on the ratios rather than on the absolute levels of these substances in the plant. In the present investigation, gibberellins, auxins and growth retardants have induced variable growth, flowering and fruiting responses in tomato and other plants. These variable responses as LEOPOLD (1955) and WITTWER—BUKOVAC (1958) stated are attributed to: a) species or variety of the plant, b) concentration of the growth substances applied and frequency of application, c) effective concentration in the tissue, d) time and method of application and e) environmental conditions.

At present there is no need to postulate a correlation between changes in vegetative

development and those of flowering and fruiting. We could perhaps account for the observed changes in flowering and fruiting solely by the changes in the ratios of growth substances in the plant.

DOSTAL—HOSEK (1937) were the first to observe that flowering of *Circaea* could be delayed or prevented by auxin and since then there has been an increasing feeling that auxin may be antagonistic to the postulated flowering hormone or florigen. FISHER—LOOMIS (1954) found that anti-auxin treatment to soybean plants induced earlier flowering than the control. Also gibberellin is now known to stimulate flowering only in some long-day plants and to delay flowering in short-day plants. Thus it behaves differently from the flowering hormone, although it may be intimately involved in flower formation.

It seems then that the balance between auxin and gibberellin which act interdependently (BRIAN—HEMMING 1957) and the flowering hormone is important in the transition from the vegetative to the flowering state. The mechanism by which auxins, GA_3 and B—995 alter the state of flowering and consequently that of fruiting can be tentatively interpreted as relating to the relative expression of the endogenous hormones and florigens; thus, the presently used growth substances may have maintained certain ratios of the hormone–florigen system which made the treated tomato plants capable of lower or higher rates of flowering and fruiting than the control. These low or high rates of flowering and fruiting may result from suppressing or augmenting the action of florigen.

The changes herein reported for growth substances of the auxin type in flower buds and young fruits (Figs 1—4) are in accord with the suggestion that the alteration in the balance of growth substances in the tomato plant occurred as a result of exogenous treatment with growth substances.

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PURCHASE PRICE DIFFERENTIATION FOR PRODUCERS' FRESH MILK ACCORDING TO QUALITY AND USEFUL MATTER CONTENT

An increasing number of countries in the world are attempting to harmonise the quality and price of their products. In Hungary the government decree No. 56/1967 (XII. 19) para. 16 and the Cabinet decision No. 2001/1974 (I. 9) prescribe the co-ordination of price and quality not only for the final product but also for the raw material.

When applying the provisions of law the price fixing authorities have to take these objectives into consideration.

The Cabinet decision 1025/1972 (VII. 30) lays down — among other things — that 1. the consumption of milk protein should be increased, 2. price policies must be elaborated to promote the work of breeding, and 3. damage caused by mastitis, including lesions caused by the milking machine, must be prevented.

A campaign aimed at increasing milk protein consumption and a price policy to promote the purchase of milk may provide substantial assistance in breeding animals with higher protein outputs.

Mastitis control and the fight against other pathological changes in the milk, which are not notifiable, can be coordinated within the government programme.

In an earlier publication we pointed out the frequent occurrence of mastitis and various pathological changes in milk caused by incorrect methods of mechanical milking, which are alien to physiological conditions, and by keeping cattle under unsuitable conditions (NYIREDY 1960, WAGNER *et al.* 1974).

As a consequence of the pathological changes there is a decrease in the fat-free dry matter content of milk, particularly in the casein, a highly important component of cheese, curd and other products made by using coagulating techniques. The quantity of whey proteins increases (both in an absolute and relative sense), and in the course of cheese-making their colloid-stabilizing effect inhibits the coagulation of casein, which is in any case only present in small quantities.

On making cheese the coagulating matter becomes a water-binding agent and in the course of maturing often appear various disadvantageous organoleptic properties (NYIREDY 1938).

Pathologically changed milk originating from diseased animals, even when present in the vat in a proportion not higher than 0.01 per cent, causes a 0.3 per cent loss of casein, while in using milk from healthy animals we only have to reckon with a 0.01 per cent loss (NYIREDY 1938).

The results of theoretical calculations made on this basis, concerning the amount of surplus milk required to produce 1 q product, are contained in Table 1.

Apart from pathological changes the reduced casein content may also be caused by watering the milk, by genetic causes or by improper feeding.

Some cattle breeds give high milk yields but their milk has a relatively low useful matter content; its casein content is generally 2.2—2.4 per cent compared to the 2.7—3.2 per cent casein content of milk produced by breeds with more concentrated milk. The fat-free dry matter content of milk naturally changes accordingly (HORN—DOHY 1970, ANAGAMA 1972).

In the coming years breeders will be called upon to develop breeds producing so-called "concentrated" milk, which will facilitate the organization of milk transport and promote the more economic production of dairy products, with the ultimate result of substantial savings

Table 1

Surplus milk required for producing 1 q cheese

Product made of pathological milk	Surplus milk used to produce 1 q cheese (litre)	Surplus milk	
		%	$
Pannónia cheese	126	11.05	11.57
Gruyère cheese	128	11.06	11.73
Parmesan cheese	147	11.13	13.48
Portsalut cheese	121	11.03	11.10
Edam cheese	123	11.04	11.28
Low-fat Óvári cheese	131	11.05	12.12
Sport cheese	53	10.93	4.87
Pálpusztai cheese	91	11.13	8.35
Low-fat cottage cheese	76	11.34	6.97

at a national economic level. In the future breeding should therefore be aimed primarily at increasing the protein and casein contents of the milk.

The casein content of the total protein should not be less than 77 per cent; lower proportions indicate the presence of pathological processes (WAGNER *et al.* 1974).

With the analytical methods currently available the amount and percentage of total proteins can be determined in some 30 minutes (WAGNER *et al.* 1974).

By proper feeding the useful matter content of milk — milk protein and casein — can be increased, taking into account the physiological limitations (CSUKÁS 1952).

Any such attempt made by the producer in co-ordination with the long-range objectives should be financially appreciated. It is a well-known fact that as a response to reduced quantities or wrong composition of feed, or in consequence of sudden changes in feeding, a decrease is observed both in the amount of milk and in its fat, protein (including casein) and fat-free dry matter content (CSUKÁS 1952).

Current purchase price of milk. With a view to the development of cattle breeding the increased purchase price of milk was fixed in 1973 at 9.24 $/hl. If this price is differentiated by the quality and surplus useful matter content of the milk the following result is obtained:

	Purchase price, $/hl	Percentage distribution of price
Annual average price of milk containing 3.6 per cent butterfat	8.34	90.2
Price for surplus butterfat (0.166%)	0.30	3.3
On the basis of quality (first class and TBC negative tested)	0.60	6.5
Total purchase price	9.24	100.0

There is little differentiation for quality in the purchase price. 73.0 per cent of the 6.5 per cent quality price is made up by the premium given for TBC-tested milk and 27 per cent is paid for first class physical purity. Three-quarters is thus paid according to the state of health of the animals, which is, of course, related to the quality of the milk, but which in fact only serves to encourage the development of TBC-free dairy-farms. If we disregard this point, the extent of price differentiation by quality amounts to some 2 per cent of the total price.

It can thus be seen that the purchase price of milk is very little differentiated according to the actual quality, despite the fact that high quality is a basic requirement.

The government programme for the development of cattle breeding and the financial incentives given within the framework of this programme should result in an abundance of milk and dairy products in Hungary.

The present consumption of milk proteins is about 50 per cent of the level required for healthy nutrition. The intensive promotion of domestic milk and dairy product consumption in Hungary is therefore justified.

A uniform supply and a wide range of high quality milk and dairy products are essential preconditions for increasing the level of consumption. Storable products with a longer period of guarantee cannot be produced from poor quality milk.

Therefore, in the coming years, besides the quantity of milk production increased attention should be paid to its quality. The purchase price — in accordance with long-range objectives — should thus be fixed in the future in such a way that adequate remuneration is given for high quality and for a correct composition of useful matter content in the milk.

Table 2

Percentage distribution of the retail price of milk for butterfat and fat-free dry matter content (at the retail price of butter, taking the fat content of retail milk as 3%)

Country	Butterfat	Fat-free dry matter	Total
	in milk		
England	14	86	100
USA	19	81	100
West Germany	30	70	100
Austria	30	70	100
France	37	63	100
Belgium	38	62	100
Bulgaria	40	60	100
Czechoslovakia	40	60	100
Italy	41	59	100
East Germany	42	58	100
Yugoslavia	43	57	100
Poland	62	38	100
Hungary	50	50	100
Hungary 1973*	36	64	100
Total	522	878	
Average	37	63	

* Not included in the average. 1970 prices for retail milk (litre) and butter (kg) expressed in national currency. Source: Central Statistical Office, 20th July 1973 (No. 17). Current statistical publications Vol. 294, "International data on food economy".

Seventy-three per cent of the present purchase price is paid for the butterfat content of the milk and 27 per cent for its fat-free dry matter content. In the purchase price 1.76 $/kg represents the butterfat and 0.30 $/kg the fat-free dry matter content. If we compare the price ratios for 1 kg butterfat and 1 kg fat-free dry matter, then 86 per cent of the price falls to the former and 14 per cent to the latter. Butterfat is thus overpaid in the purchase price. The price ratio of butterfat to fat-free dry matter in the retail price is 63 : 37. This ratio corresponds exactly with the price ratio for butterfat and fat-free dry matter in retail milk in the majority of socialist and capitalist countries (13 countries), calculated using the price of retail butter (Table 2).

When the dairy enterprises settle their mutual accounts for dairy products the prices of butterfat and fat-free dry matter are calculated at a ratio of 60 : 40 per cent.

Thus, there is every justification for developing a correct distribution ratio within the producers' and retail prices, based on useful matter content.

Within the purchase price

— the 60 : 40 ratio of value for butterfat and fat-free dry matter content should be approached;

— precise quality requirements should be fulfilled and prices should be differentiated accordingly, since good, storable products cannot be produced from poor quality raw materials;

— the purchase price should be differentiated to a considerable extent on the basis of the microbiological quality (quantity of micro-organisms) and cell number.

The high quality of the raw material is a precondition for increasing both domestic consumption and exports.

A price system developed on the basis of the butterfat content of milk naturally encourages the producer to keep cows with a high capacity for butterfat production. There would be no objection to this, provided the consumption and marketing of butterfat rise in proportion to the production, and the conditions of domestic and possible foreign relation are ensured. However, long-term conditions do not seem to justify this.

With a view to the efficient realization of the new government programme for cattle breeding greater attention should be paid in the long run to the fat-free dry matter content of milk. It is also justified by the rapid rate of increase of the amount of milk used for cheese-making and powdered milk production.

Within the fat-free dry matter content the proportion of milk proteins should be followed with increased attention, and in milks processed using a coagulation technique the casein should also be measured and evaluated.

It is desirable to introduce a system in which 8.5 per cent is the minimum proportion of fat-free dry matter content acceptable, including at least 2.8 per cent casein.

Unless increased attention is paid to these factors in the future, and milk production is co-ordinated with the interests of national economy, it will be impossible to instigate healthier nutrition habits. Hungary is still far from being in a state when unsold supplies can be spoken of as "mountains of powdered milk", but steps must be taken towards purposeful long-range planning and direction even in our present work.

It follows from the above that increased attention must be paid to the quality of milk. The technical conditions of milking, milk handling and cooling must therefore be further improved. This requirement is well on the way to fulfilment on the large dairy farms. The preservation of the high quality of milk should begin in the stable and must be ensured in the course of collecting and processing, right up to marketing.

The purchase price of milk should be differentiated according to its two main groups of useful components. In Hungary the retail price represents a 60 : 40 per cent price ratio for

Table 3

Seasonal purchase prices of milk without bonuses (1973)

	Winter season (1.12 – 30.4), $/lit.	Summer season (1.5 – 30.11), $/lit.
Basic purchase price of milk with 3.6% butterfat content (excluding bonuses paid for TBC-free, large farm and purity – tested milks)	0.08	0.07
3.6% butterfat content at 0.0015 $/lit. per 0.1%	0.05	0.05
Price of milk after deducting the price of butterfat from the basic price	0.03	0.02
Price of 0.1% casein taking 2.7% casein content as basis	0.0011	0.0007
Deduction for each 0.1% if the fat-free dry matter content is less than 8.5%	0.0005	0.0005

butterfat and fat-free dry matter. This price ratio should also be applied to the purchase prices, naturally within the current price level.

The purchase price of milk might be divided into two parts: one for the butterfat and the other for the fat-free dry matter, including the casein content.

Accordingly, if the butterfat content of the purchased milk were 3.6 per cent and the fat-free dry matter content 8.5 per cent (including at least 2.8 per cent casein), the producer would receive the present basic purchase price. If the butterfat or casein content of the milk delivered were higher than that, he would be given a premium of 1.2—1.3 $/kg for butterfat and 1.3—1.5 $/kg for casein.

Healthier nutrition involves a considerable increase in protein consumption. While an increased butterfat consumption is also justified, the main emphasis should still be laid on protein consumption. The long-range development of cattle rearing and breeding should therefore be directed towards this end.

The current purchase price of milk gives too much encouragement to the breeders and producers to develop and maintain breeds giving milk with a higher butterfat content, and fails to give an incentive for protein production, although "all over the world, of all the components of milk, the relationship between butterfat and milk protein arouses the greatest interest. The phenotypic correlation between the two properties is generally $r = 0.3—0.4$, which is somewhat lower than the genotypic correlation $r = 0.65$. According to the results of these investigations a biological correlation must exist between butterfat and milk protein formation . . . The positive correlation between butterfat and milk protein is mostly based on the relationship between fat content and casein content . . . The heritability of the butterfat and milk protein content of milk is of great importance to the breeder" (HORN 1973).

Naturally, settling the price problem is only one of the ways of approaching the subject, since the transportation and processing of milk with a lower useful matter content require a considerable cost input and extra energy, while resulting in a lower output. Therefore, in Holland and Denmark the introduction of a delivery price progressively increasing with the "concentration" of the milk is urged.

It is in the interests of both the dairy industry and of agriculture that the long-range objectives of the national economy should be realised, particularly by the development of cattle breeding.

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LEACHING OF HEAVY TEXTURED SALINE SOIL WITH DIFFERENT QUALITY IRRIGATION WATERS

It is a subject of interest to study the efficacy of the excess use of poor quality irrigation water in the desalinization of saline soil under limited drainage conditions. Various works have already been conducted on the use of saline water for reclaiming saline soils, noteworthy of which are those of TAYLOR *et al.* (1940, 1941) whose techniques, however, did not find successful applicability under all-Indian conditions. The relations between water quality and current and long-term problems of soil salinization were studied by LEATHER (1902) and TAYLOR *et al.* (1935) under certain conditions.

In the coastal areas under study, saline river water is available in abundance during the postmonsoon periods of winter and summer when, otherwise, no crop is grown due to the lack of sweet water in a sufficient amount. The soils are silty clay-loam in texture and have poor drainability. Underground water is of poor quality and is present at a shallow depth.

Saline river water was diluted to different proportions with the sweet water available to produce irrigation water of different qualities. These waters including the sweet water available were used in different amounts, equal to or in excess of the loss of moisture from the soil, as examined with a U. S. open pan Class 1 evaporimeter (P. E. T. value), and applied in plots of 2.5 m × 2.5 m borders lined by polythene sheets up to a depth of 60 cm. Wheat ("Kharchia") was grown in each plot. Considerable damage to the crop took place due to a heavy infestation of "rust" at the time of flowering and hence the crop growth data cannot be presented. The various irrigation treatments were the combinations of the following factors of quality and quantity of water:

Quality	*Quantity*
1. 2 m.mhos/cm (sweet water)	1. 3 cm against 3 cm P. E. T.
2. 4 m.mhos/cm	2. 5 cm against 3 cm P. E. T.
3. 8 m.mhos/cm	3. 7 cm against 3 cm P. E. T.
4. 12 m.mhos/cm	

Different dates of irrigation were:

(i) 19. 1. 73, (ii) 29. 1. 73, (iii) 9. 2. 73, (iv) 19. 2. 73 and (v) 28. 2. 73.

Partial drainage facilities were provided due to the existence of one 1.0 m deep open surface drain on one side of the experimental block. The drain remained partially filled with water during most of the time.

The depth of the water-table and the quality of the water in it were checked periodically for the experimental site and reported precisely along with the rainfall and the open pan evaporation data in Table 1.

Table 1

Depth and quality of water-table and meteorological data

Month	Water-table		Meteorological data	
	Depth (m), monthly average	E. Ce of water (m.mhos/cm), monthly average	Evaporation (mm), monthly average (U. S. open pan Class 1 ev·pori-meter)	Rainfall mm) daily
January '73	1.10	13.45	2.99	Nil
February '73	1.16	Not measured	3.91	11.8 (17)
March '73	1.23	10.53	5.38	8.2 (2); 6.2 (3); 2.2 (4); 16.2 (8); 2.6 (13)

Note: Figures in brackets under rainfall column indicate date.

Soil samples were collected in 0—15 and 15—30 cm layers from each plot, immediately before and 72 hours after (assuming the downward movement of the water to have practically ceased at the end of this period) each irrigation treatment (a few samples taken at the beginning of the experiment were omitted). The soils were analysed for electrical conductivity values from the saturation extract.

The initial characteristics of the soil are presented in Table 2. For each particular quality of water, different depths of irrigation water were added. The changes in the electrical conductivity values of the soil for 0—15 and 15—30 cm layers during each irrigation cycle are presented in Fig. 1.

With the increase in the concentration of salts in the irrigation water the salt concentration in the soil increased both in 0—15 and 15—30 cm layers. This applies for all depths of application of irrigation waters.

In the case of every irrigation treatment, the concentration of salts increased at the surface 0—15 cm layer during drying till the next irrigation, with a corresponding decrease in the concentration in the 15—30 cm layer, showing a contribution of salt from the 15—30 cm layer to the surface. In general, E. Ce values for both the 0—15 cm and the 15—30 cm layers tended to increase within 72 hrs of drying following each irrigation. With an increase in the

Table 2

Initial characteristics of soil

Depth (cm)	Concentration (me/l)				E. Ce (m.mhos/cm)
	Cl^-	Ca^{++}	$Ca^{++} + Mg^{++}$	Na^+	
0—15	15.6	12.0	37.0	43.4	7.02
15—30	8.6	5.0	13.0	21.7	3.58
30—45	11.6	6.0	19.0	34.8	3.80
45—60	12.6	8.0	21.0	50.0	6.43
60—75	15.6	13.6	40.0	60.8	10.22
75—90	19.6	10.6	33.0	63.0	—

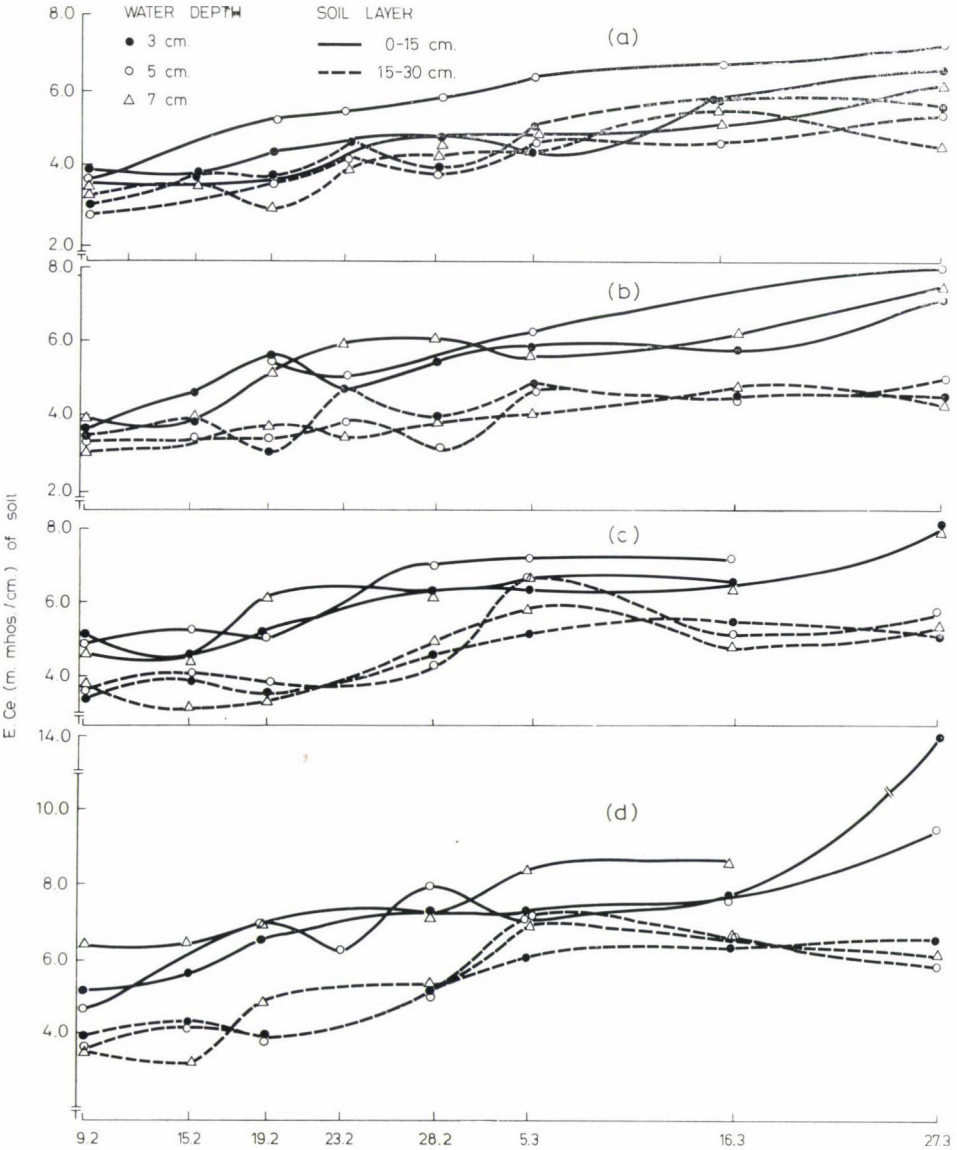

Fig. 1. Periodic changes in E. Ce values of soil irrigated with different quality waters. Date of irrigation: (i) 9.2.73, (ii) 19.2.73, (iii) 28.2.73. (a) 2 m.mhos/cm, (b) 4 m.mhos/cm, (c) 8 m.mhos/cm, (d) 12 m.mhos/cm

amount of water applied, there was an increase in the amount of salts. Interestingly it was observed that in most cases in both layers a maximum build-up of salinity was noted with the application of 5 cm of water. In the case of using 12 m.mhos/cm irrigation water, however, the application of 3 cm water showed the highest build-up of salinity in both layers. This should be due to poor soil water conductivity. The saturated hydraulic conductivity of the soil was measured *in situ* (by the auger-hole method) as 3.0 cm/day.

In the case of using 12 m.mhos/cm irrigation water, the salts deposited in the upper layers of the soil became large enough to cause flocculation of the clay, which in turn increased the rate of flow of the water into the soil (BAVER 1956). Possibly, with this additional factor to influence the flow of water into the soil, a decrease in the concentration of salts in the soil was recorded, under existing conditions, with any increase in the amount of water applied beyond 3 cm.

Though in some light textured soils the application of saline water was successful with regard to the leaching of salts, under the existing conditions of poor quality under-ground water-table, present at a shallow depth, i.e. under conditions of restricted drainage, a saline silty clay-loam soil portrays a different picture. The application of irrigation water, whether sweet (E. Ce 2 m.mhos/cm) or saline, shows a retention of salts in the soil, the extent of which increases with an increase in the amount of the total water applied, due to a greater quantity of salts poured in. When water is applied very much in excess, a decline in the tendency to retain salts is observed, probably due to a sudden jump in the rate of flow of the water.

Hence, under conditions of impaired drainage, the application of irrigation water, especially when the latter is of poor quality, increases the rate of salinization of this coastal saline soil. The efficiency of leaching may probably be increased manyfold with the creation of sufficient drainage facilities.

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EXPERIMENTS WITH CLAVICEPS PURPUREA INOCULA CONTAINING ALKALOIDS IN DIFFERENT QUANTITIES

Ergot, the sclerotium of the *Claviceps purpurea* (Fr.) Tul. fungus, developed on the rye plant, is an important pharmaceutical raw material. The collection of wild-grown *Claviceps purpurea* for the pharmaceutical industry means that the material changes in quantity and quality from year to year. It has become necessary, therefore, to produce a larger quantity of *Claviceps purpurea* of adequate uniform quality.

For the artificial infection of rye the ascospores of *Claviceps purpurea*, the diluted honeydew, or conidiospores grown on a culture medium can be used. For preparing larger quantities of inocula only the latter can be taken into account.

In Hungary larger dimension field inoculations have been carried out since 1950 with cultures grown on a malt-agar culture medium (with 8—10 per cent sugar content) suggested by BÉKÉSY (1955). Until 1952 the conidia were grown in Petri-dishes, then in "R"* kolle bottles

introduced by ROMÁN (1950); since 1955 we have been growing them in "T"* bottles as suggested by SOÓS.

The cultures have to be prepared in the 12 weeks preceding the inoculation, because senescent spores are not suitable for infection any more. DIM-ZAJEC—MASTNAK (1951) found cultures not more than 4 weeks old best fitting for infecting rye with. According to the investigations of SOÓS (1969) cultures stored for 12 weeks at room temperature yielded well too.

For inoculations in 1974 the Herbaria Co-operative Enterprise for Medicinal Plant Trade ordered 160,000 and the Kőbánya Pharmaceutics Factory 80,000 "T" bottle cultures. Owing to a shortage of autoclave capacity our Enterprise only undertook the preparation of 200,000 "T" bottle cultures. The production of this quantity took 17 weeks, therefore on the advice of Miklós Békésy we incubated the cultures for 6 weeks at 28°C then stored them in refrigerators at 9°C for 11 weeks. We have no literary data concerning the preparation of the inoculum and its storability in refrigerators for such long periods. The aims of our investigations were therefore as follows. From strains containing ergotamine (hereafter Ta.) and ergotoxine (Tox.), sent by the Research Institute for Medicinal Plants for the purpose of producing inoculum, we wished to select the ones with the best spore numbers, to examine both the change in the number of spores and the germinative ability (for 6 weeks at 28°C, then for a further 11 weeks in a refrigerator at 9°C) in inocula propagated on an agar surface, and — finally — to study in field trials the virulence of the inoculum, the amount of ergot produced and its total alkaloid content.

In the experiments ergotamine- and ergotoxine-containing strains, received from the Research Institute for Medicinal Plants for ergot production in 1974, were examined by single grain analysis using layer chromatography. Of the test-tube cultures strains 10 Ta. and 10 Tox., which gave the highest number of conidia, were chosen and multiplied in "T" bottles filled with malt-agar culture medium. For the inoculation of the surface 5 cm^3 inoculum containing 5,000 conidia per mm^3 was used. After inoculations the bottles were placed in a thermostat at 28°C, and the cultures were used for inoculum production after 21 days of incubation. Of each of a total of 5 production numbers, 4,000 "T" bottle cultures were made. The number of conidia was determined on the surface of 5 "T" bottles for each production number, in the following way: the spore content of the "T" bottle was diluted with 1,000 ml water and mixed for 5 minutes in a mechanical shaker; then the number of conidia was determined in a Bürker-chamber. The conidium numbers given in Figs 1 and 2 are the arithmetical means of 5 "T" bottles per treatment. The numbers obtained in the Bürker chamber showed — according to our experiences — a dispersion of $\pm 15\%$.

Table 1

Rye infection experiments with inocula of strains containing ergotamine and ergotoxine

Strain	Time of inoculation	Spore number in suspension used for rye infection, thousand/mm^3	Yield, kg/ha	Total alkaloid content, %
With ergotamine	11 May	10	106.67	0.46
With ergotoxine	11 May	10	105.83	0.40
L.S.D. 5%			15.33	

* The "R" kolle bottle is a 1,000 ml capacity bottle very like the kolle test tube, while the "T" bottle is a flat bottle of the same capacity.

The germinative ability of the conidia was determined: *a)* in a drop suspension on the basis of germinative ability at 27°C, and *b)* on an agar surface by the method of KYBAL *et al.* (1955). The essence of the latter, with the completion made by us, is the following: to the culture medium containing 1 per cent malt extract we added 3 per cent agar and after boiling sterilized it for 10 minutes at an atmospheric pressure of 1.5. After sterilization, 15 ml culture medium was pipetted into each of the 10 cm Petri-dishes. The Petri-dishes thus prepared were kept in the refrigerator at 2°C for 4 days, then dried at 37°C.

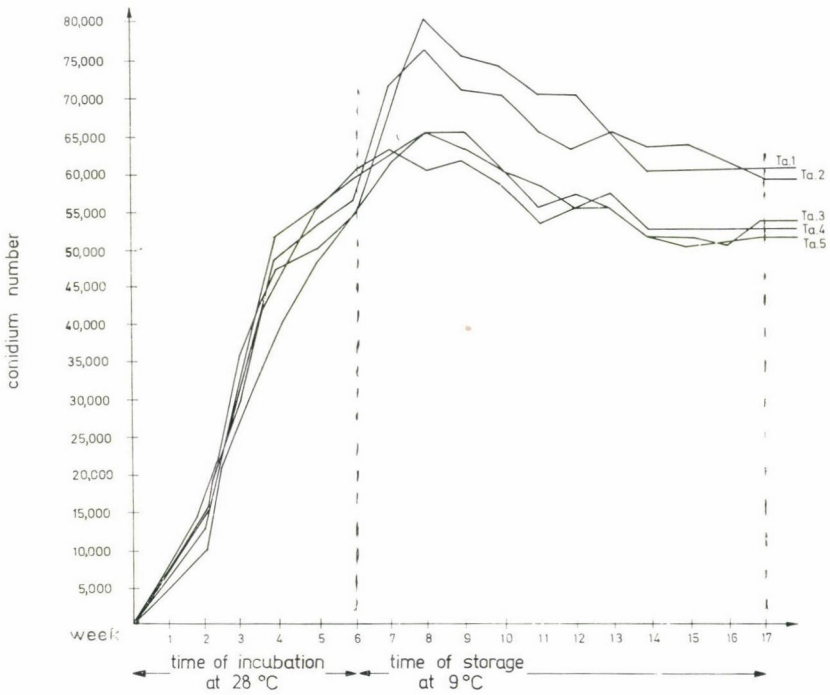

Fig. 1. Changes in the amount of conidia during 17 weeks of storage. Ta. 1—Ta. 5 = inoculum of production numbers 1—5 containing ergotamine

On the fifth day the Petri-dishes were inoculated in the following way: the content of each of the "T" bottles was mixed with 500 ml physiological water in a mechanical shaker and diluted ten- and a hundredfold. To the physiological water used for dilution, 2000 γ/ml pen icillin and 200 γ/ml streptomycin were added. From this diluted suspension 1 ml was applied to each of the agar surfaces. For each dilution 2 Petri-dishes were surface inoculated, and the suspension evenly distributed with a glass-rod. The Petri-dishes were kept at 28°C, and after 24 and 36 hours the germinative ability of the conidia was judged by counting them in 20 visual fields in two diagonal directions in the microscope and taking the average.

The small plot field trial was carried out in spring 1974 at the University of Agricultural Sciences, Gödöllő, in the middle of the rye field of the Model Farm, on plots of 5×6 m $= 30$ m^2. The trials were laid out in a Latin square design, with 4 replications for both the Ta. and Tox. strains.

Inoculation was carried out on 11th May 1974, because according to the data

of BÉKÉSY (1956) it is the most efficient when the tip of the rye ear has emerged from the leaf sheath. The spore suspension used for inoculation was prepared by stirring the contents of each "T" bottle for 5 minutes in a mechanical shaker. The infectious fluid contained 10×10^3 spores per mm^3. Inoculation was carried out using manual infecting laminae as described by BÉKÉSY (1947). Collection was made by hand.

Changes in the number of conidia (during 17 weeks) are seen in Figs 1 and 2. Both make it clear that inocula prepared on an agar culture medium can be stored for 17 weeks

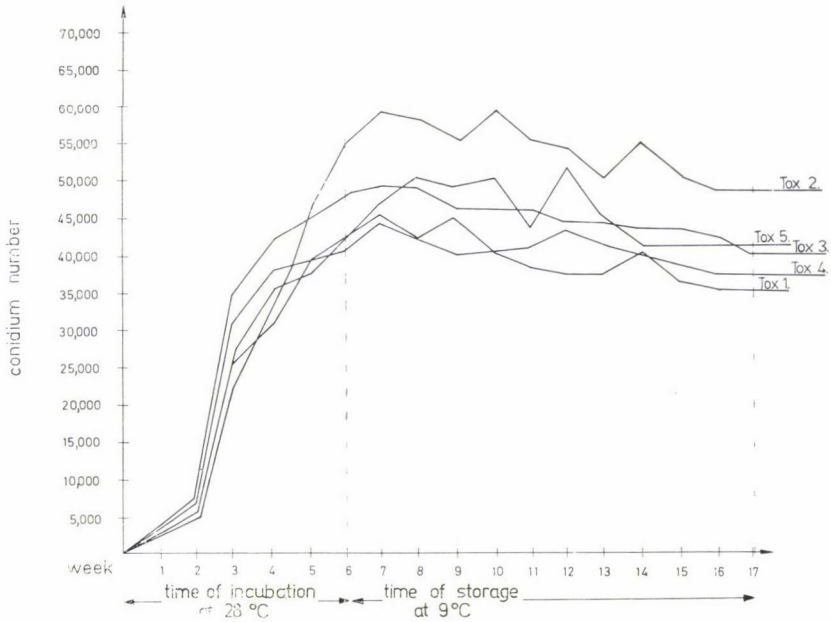

Fig. 2. Changes in the amount of conidia during 17 weeks of storage. Tox. 1—Tox. 5 = inoculum of production numbers 1—5 containing ergotoxine

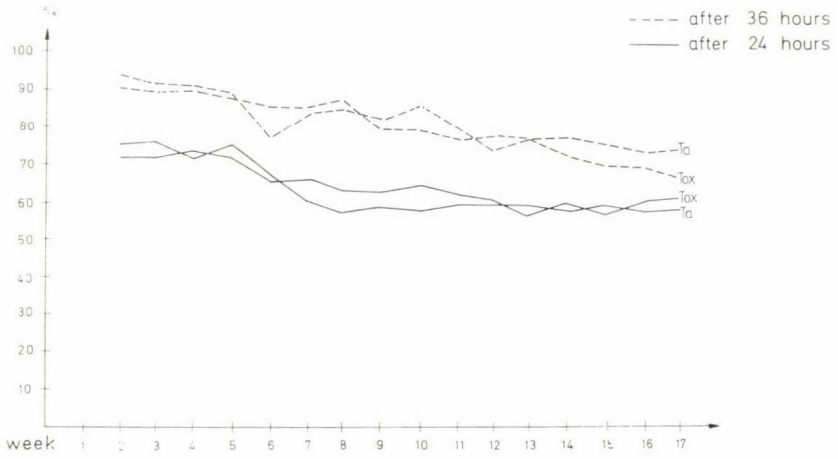

Fig. 3. Germination of conidia

under the described conditions, and used for inoculation in the field, since the decrease in the number of conidia did not exceed fifty per cent. We wish to mention that the growth of conidia agrees with the course of the well-known growth curves, but it is remarkable that in the first and even second week of storage at 9°C the detachment of spores continues, and it is only then that the cultures enter the phase of stagnation or destruction.

The germinative ability of the conidia was determined by the method, as we considered it more adequate than the drop suspension. The percentage trend of germinative ability is seen in Fig. 3, which shows that the *Claviceps purpurea* inoculum can be safely stored for 17 weeks (6 weeks at 28°C and a further 11 weeks at 9°C), since the germinative ability did not considerably decrease after this time.

Studies on virulence in the field pointed out that the two inocula resulted in identical amounts of yield — 106 kg/ha —, and there was no substantial difference in the total alkaloid content either.

*

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POSITION OF MAIZE IN THE ROTATION

II. EFFECT OF PRECEDING WINTER CROPS AND NITROGEN FERTILIZATION ON EAR CHARACTERS OF MAIZE

Corn, *Zea mays* L., is an important cereal crop in Egypt. The total area of this crop was 631,830 hectares and the total production 2,393,000 tons in 1970. It is a nitrogen loving crop which responds well to high nitrogen levels.

Many investigators were interested to study the effect of preceding crops on the yield and yield components of succeeding ones. SHARMA—SINGH (1969) concluded that increases in the grain yield of maize after legumes and after applying nitrogen were ascribed to increases in grain test weight, weight of grain per ear and ear length.

The effect of nitrogen on the yield components of maize has been studied by many investigators. HUSSEIN (1958) found that the number of ears per plant, number of rows per ear,

ear length, ear weight, weight of kernels per ear and 1000-kernel weight increased as the nitrogen level increased. RAI (1961) reported that the number of ears, 1000-kernel weight and number of grains per ear increased with increasing nitrogen level from 0 to 85 kg per hectare. The application of nitrogen to maize resulted in an increase in length and diameter of ear (HUSSEIN 1968). Average ear weight increased with increase of applied nitrogen (GAVAO *et al.* 1969). Nitrogen had a significant effect on ear weight, ear length, number of kernels per row, number of kernels per ear and weight of kernels per ear (KHALIFA 1970).

This study was intended to investigate the effect of preceding winter crops as well as the different rates of nitrogen fertilizer on the ear characters of the maize plant, which are directly related to the yield.

Materials and methods are given in detail in the first paper concerning this research (HUSSEIN *et al.* 1973). In this study the following data were recorded: Ear length, ear diameter, ear weight, number of rows per ear, number of kernels per row, number of kernels per ear and weight of kernels per ear. Data were determined from the average of a 10 ears sample, taken at random, from each sub-plot.

1. Ear length. Data on the ear length of maize plants as influenced by preceding crop and N fertilizer are shown in Table 1.

Effect of preceding crop. Preceding crop showed significant effect on ear length. Ears after legumes were significantly longer than those after non-legumes. Ears of maize plants after berseem were 0.23, 1.20, 1.35 and 1.37 cm longer than those after field beans, barley, wheat and flax, respectively. Significant differences were only found in ear length after legumes and non-legumes as two distinct groups.

It could be concluded that legumes as preceding crops had better effect on the ear length of succeeding maize plants as compared with non-legumes. This result might be due to the good residual effect of legumes and agrees with those obtained by SHARMA—SINGH (1969).

Effect of nitrogen level. Ear length increased significantly as the N level increased. Increases of 2.39 and 3.95 cm over the control were obtained due to the application of 74 and 148 kg N per hectare, respectively. This result might be attributed to the effect of N in increasing vegetative growth and meristemic activity in maize plants. Similar results were obtained by HUSSEIN (1958), HUSSEIN (1968), SHARMA—SINGH (1969) and KHALIFA (1970).

Interaction: preceding crop × nitrogen. The effect of the interaction preceding crop × nitrogen on the ear length of maize plants was not significant.

2. Ear diameter. Data on ear diameter as influenced by preceding crop and N fertilizer are shown in Table 2.

Table 1

Mean ear length in cm
(Combined analysis of 1969, 1970 and 1971 seasons)

Nitrogen kg/ha	Preceding winter crop					Mean
	Flax	Wheat	Barley	Beans	Berseem	
0	14.82	14.70	15.26	17.01	17.08	15.77 a
74	17.82	17.67	17.81	18.65	18.85	18.16 b
148	19.50	19.70	19.45	19.78	20.19	19.72 c
Mean	17.38	17.36	17.51	18.48	18.71	17.89
	a	a	a	b	b	

Table 2

Mean ear diameter, in mm
(Combined analysis of 1969, 1970 and 1971 seasons)

Nitrogen, kg/ha	Preceding winter crop					Mean
	Flax	Wheat	Barley	Beans	Berseem	
0	38.61	38.71	38.67	41.07	41.07	39.62 a
74	42.07	42.06	41.84	41.54	42.31	41.96 b
148	43.01	43.41	43.09	43.50	43.90	43.38 c
Mean	41.23	41.39	41.20	42.04	42.43	41.65
	a	a	a	a	a	

Effect of preceding crop. Ear diameter after legumes was greater than that after non-legumes, without significant differences. Ear diameter after berseem was 0.39, 1.04, 1.20 and 1.23 mm greater than that after field beans, wheat, flax and barley.

Effect of nitrogen level. The ear diameter of maize plants increased significantly as the N level increased. The application of 74 and 148 kg N per hectare increased ear diameter by 2.34 and 3.76 mm over the control.

In conclusion, N increased the ear size of maize through increasing the length and diameter of the ear. These results might be attributed to the effect of N on the growth and meristemic activity of maize. Similar results were obtained by HUSSEIN (1968).

Interaction: preceding crop × nitrogen. The effect of the interaction between preceding crop and N on ear diameter was significant. The effect of preceding crop on ear diameter was more clear where no N was applied. As the N level increased, this effect decreased. For example, ear diameter after berseem was 2.46 mm (6.3%) greater than that after flax at the lowest level of N. This difference was only 0.89 mm (2.0%) at the highest N level.

On the other hand, ear diameter showed higher response to N as maize followed non-legumes. For example, the application of 148 kg N per hectare increased ear diameter over the control by 4.40 mm (11.4%) after flax, and by 2.83 mm (6.9%) after berseem.

3. Ear weight. Data on the ear weight of maize as influenced by preceding crop and N fertilizer are shown in Table 3.

Table 3

Mean ear weight, in grams
(Combined analysis of 1969, 1970 and 1971 seasons)

Nitrogen, kg/ha	Preceding winter crop					Mean
	Flax	Wheat	Barley	Beans	Berseem	
0	109.33	105.98	117.04	136.09	147.21	123.13 a
74	154.80	152.78	152.82	161.03	171.83	158.65 b
148	182.29	187.12	182.07	166.42	180.95	179.77 c
Mean	148.81	148.63	150.64	154.51	166.66	153.85
	a	a	a	a	a	

Effect of preceding crop. The ear weight of maize plants after berseem was higher than that after all other preceding crops without significant differences. The ear weight after berseem was 12.15, 16.02, 17.85 and 18.03 grams greater than that after field beans, barley, flax and wheat, respectively.

In conclusion, berseem as preceding crop had better effect on ear weight as compared with other preceding crops. However, this effect failed to reach the level of significance.

Effect of nitrogen level. The ear weight of maize increased significantly as the N level increased. The application of 74 and 148 kg N per hectare increased ear weight significantly by 35.53 and 56.64 grams over the control, respectively.

This result is expected since N increased ear length and ear diameter, and agrees with those obtained by HUSSEIN (1958), GALVAO *et al.* (1969) and KHALIFA (1970).

Interaction: preceding crop × nitrogen. The effect of preceding crop × nitrogen interaction on ear weight was significant. The effect of preceding crop on ear weight reached its maximum where no N was applied; for example, ear weight after berseem was 37.88 grams higher than that after flax at the control level. As the N level reached 148 kg per hectare, the ear weight after flax was 1.34 grams higher than that after berseem. On the other hand, the effect of N on ear weight was more pronounced where maize followed non-legumes. For example, the application of 148 kg N per hectare increased ear weight over the control by 33.74 grams (22.9%) after berseem, and 72.96 grams (66.9%) after flax.

4. Number of rows per ear. Data for the number of rows per ear as influenced by preceding crop and N fertilizer are shown in Table 4.

Effect of preceding crop. Preceding crop had no significant effect on number of rows per ear. It seems that the number of rows per ear is genetically determined and is not greatly influenced by environmental conditions.

Effect of nitrogen level. Number of rows per ear increased significantly due to the application of N. The application of 148 kg N per hectare increased the number of rows per ear significantly over the control, while the level of 74 kg N per hectare failed to cause significant increase. Numbers of rows per ear were 13.03, 13.33 and 13.50 for the N levels of 0, 74 and 148 kg per hectare respectively.

The effect of N in increasing the number of rows per ear might be attributed to the increase in meristemic activity. Similar results were obtained by HUSSEIN (1958).

Interaction: preceding crop × nitrogen. The effect of the interaction between preceding crop and N on the number of rows per ear was not significant.

5. Number of kernels per row. Data on the number of kernels per row as influenced by preceding crop and N fertilizer are shown in Table 5.

Table 4

Mean number of rows per ear
(Combined analysis of 1969, 1970 and 1971 seasons)

Nitrogen, kg/ha	Preceding winter crop					Mean
	Flax	Wheat	Barley	Beans	Berseem	
0	13.07	12.65	13.14	13.26	13.06	13.03 a
74	13.58	13.40	13.54	13.01	13.14	13.33 ab
148	13.65	13.48	13.48	13.30	13.59	13.50 b
Mean	13.43	13.18	13.39	13.19	13.26	13.29
	a	a	a	a	a	

Table 5

Mean number of kernels per row
(Combined analysis of 1969, 1970 and 1971 seasons)

Nitrogen, kg/ha	Preceding winter crop					Mean
	Flax	Wheat	Barley	Beans	Berseem	
0	31.52	32.28	32.19	36.96	36.01	33.79 a
74	37.85	37.62	38.77	40.29	41.13	39.13 b
148	42.38	42.54	42.43	43.80	42.65	42.76 c
Mean	37.25	37.48	37.80	40.35	39.93	38.56
	a	a	a	b	b	

Effect of preceding crop. Preceding crop had significant effect on the number of kernels per row. The number of kernels per row after legumes exceeded significantly that after non-legumes. Numbers of kernels per row after field beans were 0.42, 2.55, 2.87 and 3.10 greater than those after berseem, barley, wheat and flax, respectively. Significant differences were only found in number of kernels per row after legumes and non-legumes as two distinct groups.

This result is logical since ear length was significantly influenced by preceding crop.

Effect of nitrogen level. Number of kernels increased significantly as the N level increased. The application of 74 and 148 kg N per hectare increased significantly the number of kernels per row by 5.34 and 8.97, respectively over the control. This result is expected since N increased significantly the ear length of maize, and agrees with those obtained by HUSSEIN (1958) and KHALIFA (1970).

Interaction: preceding crop × nitrogen. The effect of the interaction between preceding crop and N fertilizer on the number of kernels per row was not significant.

6. Number of kernels per ear. Data for the number of kernels per ear as influenced by preceding crop and N fertilizer are shown in Table 6.

Effect of preceding crop. The number of kernels per ear after legumes was higher than that after non-legumes, without significant differences. Number of kernels per ear after field beans was 0.51, 28.60, 33.14 and 36.04 higher than that after berseem, barley, flax and wheat, respectively.

Table 6

Mean number of kernels per ear
(Combined analysis of 1969, 1970 and 1971 seasons)

Nitrogen, kg/ha	Preceding winter crop					Mean
	Flax	Wheat	Barley	Beans	Berseem	
0	412.21	410.20	422.11	485.01	465.83	439.07 a
74	514.55	498.95	523.25	529.38	539.71	521.17 b
148	564.99	573.83	559.92	576.73	584.04	571.90 c
Mean	497.23	494.33	501.76	530.37	529.86	510.71
	a	a	a	a	a	

Table 7

Mean weight of kernels per ear, in grams
(Combined analysis of 1969, 1970 and 1971 seasons)

Nitrogen, kg/ha	Preceding winter crop					Mean
	Flax	Wheat	Barley	Beans	Berseem	
0	91.94	90.33	100.20	113.62	125.71	104.36 a
74	132.49	128.93	130.92	135.92	147.08	135.07 b
148	153.83	156.28	154.92	142.06	154.03	152.22 c
Mean	126.09	125.18	128.68	130.53	142.27	130.55
	a	a	a	a	b	

Effect of nitrogen level. The number of kernels per ear increased significantly as the N level increased by 82.10 (18.7%) and 132.83 (30.2%) over the control due to the application of 74 and 148 kg N per hectare, respectively.

This result is expected since N increased significantly ear length, ear diameter, ear weight, number of rows per ear and number of kernels per row. Similar results were obtained by HUSSEIN (1958), RAI (1961) and KHALIFA (1970).

Interaction: preceding crop × nitrogen. The effect of the interaction between preceding crop and N on number of kernels per ear was not significant.

7. *Weight of kernels per ear.* Data on the weight of kernels per ear as affected by preceding crop and N fertilizer are shown in Table 7.

Effect of preceding crop. Berseem was significantly superior to all other preceding crops in its effect on weight of kernels per ear which was 11.74, 13.59, 16.18 and 17.09 grams higher than that after field beans, barley, flax and wheat, respectively.

This result is logical since ear weight after berseem was considerably higher than that after all other preceding crops.

Effect of nitrogen level. Weight of kernels per ear increased significantly as the N level increased. The application of 74 and 148 kg N per hectare increased significantly the weight of kernels per ear by 30.73 and 47.88 grams, respectively over the control.

This result is expected since N increased significantly ear weight, number of kernels per ear, number of kernels per row, ear length and ear diameter. Similar results were obtained by HUSSEIN (1958), SHARMA—SINGH (1969) and KHALIFA (1970).

Interaction: preceding crop × nitrogen. The effect of the interaction between preceding crop × nitrogen on weight of kernels per ear was significant. The effect of preceding crop on weight of kernels per ear was very clear at the control level. As the N level increased this effect was greatly minimized. For example, the weight of kernels per ear after berseem exceeded that after flax by 33.77 grams (36.7%) at the control level, and by 0.20 grams (0.13%) at the highest N level.

On the other hand, the application of 148 kg N per hectare increased weight of kernels per ear by 28.32 grams (22%) after berseem and by 61.89 grams (67%) after flax.

*

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FRUCTIFICATION IN SOME SOUR CHERRY VARIETIES AND HYBRIDS

In Hungary, Pándy meggy, and various types of Cigány meggy used as pollen donors, are the most wide-spread sour cherries, other varieties have hardly been grown. One of the major obstacles to the extension of sour cherry production was that Pándy meggy yielded very poorly in certain years.

The variety Pándy meggy is completely self-sterile. Even when planted with suitable pollen donor varieties it is not every year that it gives a quantity of fruit corresponding to the size and condition of the tree. Pándy meggy trees have not much pollen; the pollen grains stick together and are highly irregular. In certain years the macrospore shows a deficient fertility even in the case of abundant pollination, which leads to an excessive zygotic sterility and a drop in the yield. Late flowering is also an obstacle to interpollination in Pándy meggy.

The research work was concerned first of all with the selection of pollen partners for Pándy meggy and with clone selection (MAGYAR 1935, MALIGA 1942, 1944, 1953, 1954, 1970, HUSZ 1943, MIGEND 1964, NYUJTÓ 1966, 1967, BRÓZIK 1968, 1969, BRÓZIK *et al.* 1974, NYÉKI 1974b, TAMÁSSY *et al.* 1974, 1975). According to the results of our investigations late flowering cherry varieties, some Cigány meggy types and sour cherry varieties are the best pollen donors for the variety Pándy meggy.

Pollen donor varieties recommended on the basis of fructification studies did not solve the problem of reliable production in the variety Pándy, therefore new varieties had to be developed as well. In Hungary a systematic breeding work by crossing was started in Pándy meggy by Maliga in 1950, and in other sour cherry varieties by Tamássy in 1954. A parallel selection of the Pándy clone and Cigány meggy populations and clones is being continued. As a result of breeding by crossing and of selection a considerable number of new sour cherry varieties and clones have been introduced in commercial production (e.g. Érdi bőtermő, Érdi nagygyümölcsű, Meteor korai, Favorit, Késői Pándy, Cigánymeggy—60, Újfehértói fürtös).

In earlier papers we analysed self- and cross-pollination in sour cherry varieties and hybrids (TAMÁSSY *et al.* 1974, 1975). In the present paper the following questions are examined:

1. What tendency is there towards self-pollination in the sour cherry varieties Early Richmond—502 and Montmorency—501, and the prospective varieties Hybrid—105/5 and Hybrid—106/6?

2. To what percentage are the selected Pándy meggy clones (P—1, P—8, P—279; P—7, P—10—1, P—25, P—26, P—48, P—141) and self-steril Cigánymeggy types (Törökmeggy, Cigánymeggy—60) fertilized by the sour cherry varieties Early Richmond—502 and Montmorency—501 and the prospective varieties Hybrid—105/5 and Hybrid—106/6?

The knowledge of self- and cross-pollination not only offers a possibility of selecting varieties and clones with the highest possible productivity and production reliability, but also provides a basis for evaluating the existing sour cherry varieties, producing new ones and studying the course of transmission.

Fructification studies were carried out from 1971 to 1974 partly on the Szigetcsép experimental area of the Department of Plant Genetics and Breeding at the University of Horticulture, in a sour cherry variety collection and hybrid plot planted in autumn 1965 and 1967, at a spacing of 6×4 m with trees of medium high trunk, crown shaped with a leader and *Prunus mahaleb* seedlings as root-stock, and partly at the Érd-Elvira Station of the Horticultural Research Institute in a variety collection planted in autumn 1955 at a spacing of 8×8 m with trees of medium high trunk, crown trained with a leader, grafted to *Prunus mahaleb* stocks.

In order to throw light on the question of self-pollination the following examinations were performed:

Isolation without artificial pollination. Closed flower buds were counted and isolated without artificial pollination up to the end of flower shedding. In this treatment pollination can take place only inside the isolator.

Isolation, artifical pollination with the variety's own pollen. Flowers isolated when the buds had all opened in the isolators, were pollinated with their own pollen and kept in the isolators till the end of flower shedding.

Cross-pollination (search for pollen donors). The fertilizing ability of pollen from the would-be pollen donors can only be assessed if the flowers' own pollen is prevented from reaching the stigma. In self-sterile sour cherry varieties and clones the flowers were not castrated before being pollinated with the pollen of the chosen pollen donor varieties.

In the course of fructification studies the flower buds were isolated with waterproof parchment bags measuring 25×25 cm to exclude the possibility of cross-pollination. Pollen was collected and pollination carried out with the method described by NYÉKI (1975). The fructification percentage was determined on the basis of 5—35 fruits per combination, set in an isolator.

The number of flowers per isolator pollinated in each treatment was 20—150 depending on the variety (clone). Fruit setting was evaluated on three occasions: after "cleaning" and "red" fruit drop and at the time of ripening. This paper presents the percentage of fruit setting (of ripe fruits).

Self-pollination. Self-pollination of sour cherry varieties and hybrids is seen in Table 1. Percentage fruit setting in the case of natural autogamy was 0.3—19.5 per cent, while with clone-geitonogamic pollination it ranged between 27.6 and 30.8 per cent.

On the basis of percentage fruit setting we divided the sour cherry varieties into three groups (NYÉKI 1974a, TAMÁSSY *et al.* 1975). Fruit setting is above 5 per cent in self-pollinating varieties, ranges from 1.1 to 5.0 per cent in partially self-pollinating ones and is between 0 and 1.0 per cent in self-sterile varieties. According to the percentage of fruit setting resulting from natural autogamic and clone-geitonogamic pollination the examined varieties (Early Richmond—502 and Montmorency—501) and prospective varieties (Hybrid—105/5 and Hybrid—106/6) were self-fertile.

Clone-geitonogamic pollination increased the percentage of fruit setting in the prospective varieties Hybrid—105/5 and Hybrid—106/6 compared to natural autogamy. Fruit setting was 18.5 and 19.5 per cent higher in 1971 and 1972 respectively in Hybrid—105/5, and 20.1,

Table 1

Self-fertility in sour cherry varieties and hybrids
(1971—1973, Szigetcsép)

Variety	Year	Natural autogamy		Clone-geitonogamic pollination	
		number of isolated flowers	fruit setting, %	number of pollinated flowers	fruit setting, %
Early Richmond—502	1971	115	6.9		
	1972	140	6.4		
	1973	676	9.6		
Montmorency—501	1971	143	19.5		
	1972	162	16.0		
	1973	332	14.5		
Hybrid—105/5	1971	142	9.1	253	27.6
	1972	122	8.2	167	27.7
	1973	863	0.0*	241	0.0*
Hybrid—106/6	1971	138	10.1	225	30.2
	1972	144	15.9	337	30.8
	1973	349	0.3	159	28.3

* In 1973 the flowers got frost-bitten.

15.3 and 28.0 per cent higher in 1971, 1972 and 1973 respectively in Hybrid—106/6, than in the case of natural autogamy.

Cross-pollination. When choosing the pollen donor varieties the time of flowering must also be taken into consideration. It is an important requirement that the flowering time of the pollen donor variety should overlap, and its main blossoming coincide with the flowering period of the variety to be pollinated. Only varieties belonging to the same or adjacent flowering-time groups are suitable to be pollen donors.

Major sour cherry and cherry varieties (clones) have been grouped according to the time of mass flowering (Brózik 1968, 1969, Brózik *et al.* 1974, Nyéki 1974a, b). In the present paper the sour cherry varieties, clones and hybrids are divided into three groups of flowering times (early, medium and late) on the basis of observations made at Szigetcsép (Table 2).

Fruit setting in Pándy meggy clones. The pollination of Pándy meggy clones by sour cherry hybrids is shown in Table 3. According to the results of our investigations both sour cherry hybrids proved to be good pollen donors for the Pándy meggy clones. Hybrid—105/5 produced 19.1—26.1 per cent, Hybrid—106/6 23.7—31.2 per cent fruit setting in the clones examined.

The results of pollination of Pándy meggy clones by sour cherry varieties and hybrids are seen in Table 4. The data of Table 4 confirm the results of observations made at Szigetcsép (Table 3), namely, that the sour cherry hybrids 105/5 and 106/6 are very good pollen donors for the Pándy meggy clones examined; with their pollen a high percentage of fruit setting can be attained. The pollen of Hybrid—105/5 produced 3.8—23.4 per cent, that of Hybrid—106/6 3.3—30.3 per cent fruit setting in the different Pándy meggy clones.

Table 2

Sour cherry varieties, clones and hybrids grouped by the time of flowering (1971—1974, Szigetcsép)

Group of flowering time		
early	medium	late
Early Richmond—502	Montmorency—501	Pándy meggy (irradiated)
Pándy meggy—8	Hybrid—106/6	Pándy meggy—4
Pándy meggy—1	Hybrid—105/5	Pándy meggy—279
	Pándy meggy—5	Schattenmorelle
	Pándy meggy—114	

Table 3

Fructification induced by sour cherry hybrids in Pándy meggy (1971—1973, Szigetcsép)

♀ \ ♂	Year	Hybrid—105/5	Hybrid—106/6
Pándy meggy (commercial)	1971	115 : 23.4	
	1972	153 : 22.8	187 : 31.0
	1973	180 : 26.1	192 : 31.2
Pándy meggy—1	1972	165 : 21.2	144 : 25.0
Pándy meggy—8	1972	—	189 : 26.1
	1973	130 : 23.1	129 : 28.6
Pándy meggy—279	1972	147 : 21.1	—
	1973	215 : 19.1	232 : 23.7

Note: the first figure represents the number of pollinated stigmae, the second is the percentage of fruit setting.

The sour cherry varieties Early Richmond—502 and Montmorency—501 proved to be equally good pollen donors.

Fruit setting in Cigány meggy types. The fructification induced by sour cherry varieties and hybrids in self-sterile Cigány meggy types (Török meggy, Cigány meggy—60) is shown in Table 5. The sour cherry varieties Early Richmond—502 and Montmorency—501, and the sour cherry hybrids 105/5 and 106/6 were not found to be good pollen donors for the Cigány meggy types examined, as indicated by the low percentages of fruit setting.

Clone-geitonogamic pollination increased the percentage of fruit setting in self-fertile sour cherry varieties and hybrids compared to natural autogamy. This suggests that without an intermediary (bee, wind) the amount of pollen reaching the stigma is not always enough. It is therefore better to place bee families in the orchard during the time of flowering even in the case of self-fertile varieties.

Early Richmond—502, Montmorency—501 and the sour cherry hybrids 105/5 and 106/6 induced a varying extent of fruit setting in the sour cherry varieties (clones and types), proved to be good pollen donors for the Pándy meggy clones and unsuitable for the Cigány meggy

Table 4

Fructification induced by sour cherry varieties and hybrids in Pándy meggy clones
(1973—1974, Érd-Elvira)

♀ \ ♂	Year	Hybrid—105/5	Hybrid—106/6	Early Richmond—502	Montmorency—501
Pándy meggy—7	1973	97 : 20.6	142 : 19.0	132 : 9.1	—
	1974	328 : 22.8	208 : 24.9	241 : 10.3	—
Pándy meggy—10—1	1973	141 : 8.5	182 : 3.3	134 : 7.5	—
	1974	456 : 10.5	320 : 8.7	259 : 11.2	—
Pándy meggy—25	1973	109 : 8.3	162 : 27.8	127 : 0.0	—
	1974	279 : 10.4	310 : 30.3	257 : 8.5	110 : 18.2
Pándy meggy—26	1973	—	—	—	90 : 6.7
Pándy meggy—48	1974	181 : 3.8	181 : 18.8	—	174 : 11.5
Pándy meggy—141	1973	154 : 23.4	84 : 29.8	94 : 2.1	102 : 2.0
	1974	435 : 22.0	328 : 26.5	271 : 6.6	388 : 4.3

Note: the first figure represents the number of pollinated stigmae, the second is the percentage of fruit setting.

Table 5

Fructification induced by sour cherry varieties and hybrids in self-sterile Cigány meggy types
(1973, Érd-Elvira)

♀ \ ♂	Early Richmond—502	Montmorency—501	Hybrid—105/5	Hybrid—106/6
Török meggy	186 : 2.7	243 : 3.3	109 : 0.0	153 : 1.3
Cigány meggy—60	144 : 0.0	101 : 0.0	135 : 5.2	127 : 2.4

Note: the first figure represents the number of pollinated stigmae, the second is the percentage of fruit setting.

types. Certain combinations showed a one-sided incompatibility (e.g. Török meggy × Hybrid—105/5; Cigány meggy—60 × Early Richmond—502; Cigány meggy—60 × Montmorency—501).

In our investigations the completely self-sterile types of Pándy meggy were made highly fertile by the pollen of hybrids 105/5 and 106/6.

*

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INCREASING SALT TOLERANCE OF WHEAT AT EARLY STAGES OF GROWTH UNDER CHLORIDE AND SULPHATE TYPES OF SALINITY

The wheat plant is generally known to be medium salt tolerant (STROGONOV 1962), yet germinating seeds and seedlings in their early stages of growth were reported to be highly susceptible to salinity (MALEWAL—PALEWAL 1967). Under saline conditions the magnitude of reduction in seed germination and seedling growth of different plant species was found to vary according to the type of salinity (KADDAH 1963, HASSON-PORATH *et al.* 1972).

Some attempts were made to induce salt tolerance by soaking the seeds, before sowing, in solutions containing certain trace elements (SHKOLNIK 1939). In previous field experiments with wheat (BAKR AHMED *et al.* 1970) it was found that under saline irrigation conditions presowing soaking of seeds in a solution containing 50—500 ppm boric acid caused increases in the yield of grains per unit area. HENCKEL (1960) showed that under a sulphate type of salinity presowing soaking of seeds in a solution containing 2000 ppm $MgSO_4$ increased the salt tolerance of the developed seedlings.

The aim of this work was to investigate the germination of salt-hardened wheat seeds as affected by chloride and sulphate types of soil salinity, as well as the growth and the chemical constituents of the developed seedlings.

This work was carried out in the National Research Centre. Wheat seeds *(Triticum vulgare)* cv. Giza—155 were used in these studies. Glazed earthenware pots, 15 cm in diameter and 8 cm in depth, each containing 1.5 kg dry clay loam soil (pH 7.9) were prepared. The soil was artificially salinized with mixtures of salts inducing chloride or sulphate salinization as described by STROGONOV (1962) and presented in Table 1. Four levels of soil salinity: 3.5 (control), 4.5, 5.5 and 6.5 mmhos/cm² at 25°C for 1 : 5 soil–water extract, were being tested. Such saline levels were attended by the addition of the following amounts of salt mixtures based on the dry weight of the soil: 0.0 (control), 0.2, 0.4 and 0.6% salts in the case of the chloride experiment, and 0.0 (control), 0.4, 0.8 and 1.2% salts in the case of the sulphate experiment. The salt mixtures were dissolved in tap water and added to the soil ten days before sowing.

Table 1

The components of salt mixtures used to induce chloride and sulphate types of salinity (STROGONOV 1962)

Type of salinity	Per cent of the total salt content						Per cent of the total meq.					
	Na_2SO_4	$MgSO_4$	$CaSO_4$	NaCl	$MgCl_2$	$CaCO_3$	Na^+	Mg^{++}	Ca^{++}	$SO_4^{=}$	Cl^-	$CO_3^{=}$
Chloride	—	10	1	78	2	9	38	6	6	5	40	5
Sulphate	35	28	20	10	—	7	21	15	14	40	6	4

The wheat seeds for both the cloride and the sulphate types of saline experiments were divided into two groups. The first group of seeds for the chloride experiments was soaked in a solution containing 100 ppm H_3BO_3 for 48 hours, while that for the sulphate experiments was soaked in a solution containing 2000 ppm $MgSO_4$ for 24 hours. The second group of seeds for both types of saline experiments were soaked in distilled water for the same period. The treated seeds were dried with filter paper and twenty seeds were sown in each pot at a constant depth of 2 cm. Every treatment had six replicates, each was represented by one pot. Moisture in the soil was kept at 60—65% of the total water holding capacity of the soil throughout the experimental period.

After one month from sowing different measurements were taken. The germination capacity of seeds was determined according to the following formula:

$$\frac{\text{Maximum number of the emergent seedlings} \times 100}{\text{Total number of seeds}}$$

From the fresh leaf-blades of the young seedlings the photosynthetic pigments were extracted with 80% acetone, using the method described by BRUINSMA (1963), then identified in a Spekol type spectrocolorimeter (Zeiss, Jena). The whole wheat seedlings were carefully removed from

the pots and their roots were thoroughly washed with running water and separated from the shoots. The shoot and the root were separately dried in an air-draft oven adjusted at 70°C till constant weight was obtained. The crude dry material of the shoots was subjected to chemical analysis. Total and soluble nitrogen was determined using the micro-Kjeldahl method, then protein nitrogen was calculated. Determination of phosphorus was carried out colorimetrically according to KING (1951), while determination of potassium and sodium was performed using Carl Zeiss Flamephotometer. Calcium was determined using the U. V.-EDTA

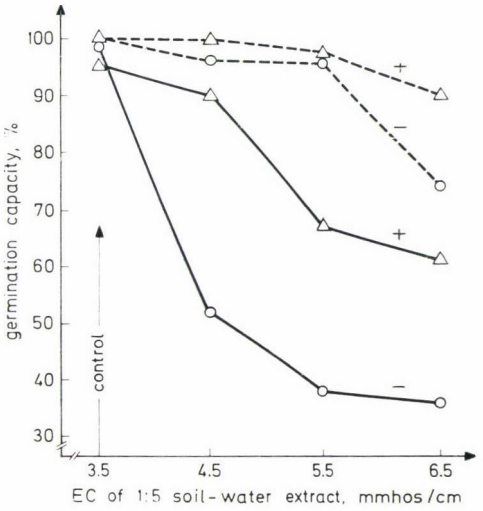

Fig. 1. Effect of chloride (—⊙—&—△—) and sulphate (- - -○- - -&- - -△- - -) types of salinity and salt hardening on germination capacity of wheat seeds. (—) Without hardening, seeds soaked in water in both types of saline experiments: (+) seeds soaked in H_3BO_3 in chloride experiment or in $MgSO_4$ in sulphate experiment (LSD for chloride exp. = 9.43; LSD for sulphate exp. = 5.57)

titration method originally described by Szakes Biemer and modified by ABDEL-HALIM (1964) using "Calcein" as indicator.

The obtained data were subjected to the statistical analysis of variance and the values of the LSD were calculated whenever the calculated "F" values were significant at 5% level of probability.

Germination capacity of seeds. Fig. 1 shows that the germination capacity of wheat seeds decreased markedly with increasing the level of chloride soil salinity. Sulphate salinity, on the other hand, did not reduce the capacity of seeds to germinate, except at the highest level. Presowing salt hardening of seeds with boric acid could overcome to some extent the retarding effect of chloride salinity on seed germination as compared with water soaked seeds. The germination capacity of wheat seeds under the highest level of chloride salinity was nearly doubled, when the seeds were salt hardened with boric acid. Under sulphate type of salinity, presowing seed hardening with $MgSO_4$ according to Henckel's method proved to be effective in increasing the germination capacity of wheat seeds at the highest level of salinity from 75% up to 90%.

The higher depressing effect of chloride than of sulphate salinity on seed germination and seedling growth was reported by KADDAH (1963) on rice, and by HASSON-PORATH *et al.* (1972) on peas. The observed reduction in seed germination under salinization conditions was sug-

gested to be due to the inhibition of colloidal imbibition or/and the specific toxic effects of the salts on the embryos (STROGONOV 1962).

Treating seeds with boric acid was reported to enhance the activity of hydrolytic enzymes (VLASIUK 1969) in the germinating seeds. Such effects may cause an increase in the osmotic pressure of the cell sap, and in turn, could offset the osmotic unbalance between the germinated seeds and the ambient solution. HENCKEL (1960) also concluded that, under sulphate salinity, salt hardening of seeds with $MgSO_4$ may reduce the uptake of SO_4 ions, and this in turn may increase the salt tolerance of the germinated seeds.

Growth of seedlings. Table 2 demonstrates that increasing the level of chloride salinity caused progressive and consistent reduction in the dry matter content of both shoot and root of the developed wheat seedlings. However, the shoot was more severely affected with chloride salinity than the root, since shoot/root ratio showed a decrease. The same table also shows that if wheat seeds were salt hardened with boric acid before sowing, the dry matter accumulation by the developed seedlings was improved as compared with that of water soaked seeds.

Sulphate salinity, at low level had no effect on the dry weight of the shoot and root of the developed seedlings, but significant reductions in shoot growth were observed thereafter. The shoot/root ratio tended to decrease with increasing the level of sulphate salinity. The dry matter accumulation showed no significant increase when the seeds were treated with $MgSO_4$ solution.

The higher adverse effects of chloride than sulphate salinity on the growth and the dry matter content of seedlings and especially that of the above-ground part were reported by STROGONOV (1962) using different plant species. The ability of the plants to adjust the osmotic potential of the media induced by different types of salinity may be of great importance. HASSON-PORATH *et al.* (1972) found that pea plants grown in sulphate salinized media adjusted

Table 2

Effect of chloride and sulphate types of salinity and salt hardening of seeds on dry weight of wheat seedlings (g/100 plant)

EC of 1 : 5 soil—water ext., mmhos/cm	Hardening of seeds*	Chloride salinity				Sulphate salinity			
		Shoot	Root	Whole plant	Shoot/ root	Shoot	root	Whole plant	Shoot/ root
3.5	—	6.50	5.00	11.50	1.29	6.88	5.92	12.80	1.16
	+	6.92	5.03	11.95	1.36	6.83	5.33	12.17	1.28
4.5	—	4.42	3.92	8.33	1.13	6.20	5.75	11.95	1.07
	+	5.25	4.75	10.00	1.11	6.67	6.00	12.67	1.11
5.5	—	3.38	3.23	6.62	1.04	5.00	4.68	9.68	1.07
	+	4.08	3.97	8.05	1.03	5.52	5.08	10.60	1.09
6.5	—	2.55	2.45	5.00	1.04	3.38	3.80	7.38	0.95
	+	3.13	3.17	6.30	0.99	4.00	4.05	8.03	0.96
LSD 0.05		0.54	0.48	1.04	—	0.56	0.61	1.13	—

* (—) Without hardening; seeds soaked in water for both types of saline experiments.
(+) Seeds soaked in boric acid for chloride experiment or in magnesium sulphate for sulphate experiment.

fully to the change in the external osmotic potential, which did not occur with chloride salinity, where the osmotic potential decreased constantly with increasing ambient salinity. In addition, the accumulation of some intermediate toxic compounds such as petroscine and cadavarine (STROGONOV *et al.* 1970, ASHOUR—THALOOTH 1971b) in chloride salt-affected plants, and sulphoxides and sulphones in sulphate salt-affected plants (SHEVYAKOVA—STROGONOV 1968) may play a role in the growth depression of young seedlings.

The improved growth of chloride salt-affected seedlings due to presowing salt hardening of seeds may be attributed to the mitigating effect of boric acid on the physico-chemical properties of plant cell protoplasm biocolloids, i.e., decreasing its permeability and increasing its viscosity (SLONOV 1966).

Content of chlorophyll and carotenoids in leaf blades. Table 3 shows that chloride salinity caused significant reduction in the concentration of chlorophyll a + b, but did not significantly change that of carotenoids in the leaf blades of the developed seedlings. Thus, the chl. a + b/carotenoid ratio tended to decrease in chloride-salt affected seedlings. The ratio of chl. a/b tended to increase under saline conditions indicating that the concentration of chlorophyll b was reduced to a greater extent than that of chlorophyll a.

The same table shows that if wheat seeds were soaked in boric acid before sowing in chloride saline soil, the leaf blades of the developed seedlings accumulated a higher amount of chlorophyll a + b and more or less similar amounts of carotenoids as compared with those of the controls. Thus, the chl. a + b/carot. ratio showed increases due to such seed hardening treatment, whereas the chl. a/b ratio tended to decrease in hardened seedlings, indicating higher increases in the concentration of chlorophyll b than in that of chlorophyll a.

The same table also shows that under sulphate salinity, the concentration of chlorophyll a + b and carotenoids was not significantly affected, except at the highest salinity level,

Table 3

Effect of chloride and sulphate types of salinity and salt hardening of seeds on the photosynthetic pigment content in leaf blades of wheat seedlings (mg/g dry wt.)

EC of 1 : 5 soil—water ext., mmhos/cm	Hardening of seeds*	Chloride salinity				Sulphate salinity			
		Chl. a + b	Carot-enoids	Chl. a/b	Chl. a + b/ carot.	Chl. a + b	Carot-enoids	Chl. a/b	Chl. a + b/ carot.
3.5	—	9.67	3.15	2.70	3.07	9.99	3.29	2.74	3.04
	+	10.71	3.17	2.65	3.38	11.39	3.95	3.11	2.88
4.5	—	7.32	2.84	3.35	2.58	10.37	3.43	3.03	3.02
	+	9.37	2.53	2.36	3.72	11.14	3.84	2.61	2.90
5.5	—	7.28	2.67	3.72	2.73	9.95	3.34	2.53	2.98
	+	8.93	2.36	2.24	3.75	9.90	3.58	2.58	2.77
6.5	—	7.12	2.85	3.17	2.50	11.40	3.40	2.46	3.35
	+	9.13	2.64	2.08	3.48	12.81	4.17	2.60	3.07
LSD 0.05		0.63	N.S.	—	—	0.80	N.S.	—	—

* See Table 2.

where a significant increase in the concentration of chlorophyll a + b was observed. However, under such conditions, the increase in the concentration of chlorophyll a was less than in that of chlorophyll b, since the chl. a/b ratio tended to decrease The chl. a + b/carotenoid ratio did not change in sulphate salt-affected seedlings, except at the highest saline level where it tended to increase.

At the highest level of sulphate salinity, treating seeds with $MgSO_4$ increased the content of chlorophyll a + b, but did not change the ratios of either chl. a/b or chl. a + b/carot., as compared with the case of water-soaked seeds.

The differential effect of chloride and sulphate types of salinity on chlorophyll accumulation in plant tissues was also detected by DOSTANOVA (1966) at high saline level. The decrease in the amount of non-stable chlorophyll (ASHOUR—THALOOTH 1971a), and the disruption in the chloroplast structure (LAPINA *et al.* 1968), under chloride saline conditions may explain partially the reduction in chlorophyll content under such conditions. On the other hand, the observed increase in the concentration of chlorophyll a + b in the salt hardened wheat seedlings as compared with the control may be due to the increase of chlorophyll stability (SOLOVYOV—MAKAROVA 1960). The increase in chlorophyll content under high sulphate saline conditions was also reported by DOSTANOVA (1966) and STROGONOV *et al.* (1970).

Content of nitrogen fractions in shoot. Table 4 shows that chloride salinity increased the concentration of protein-N and total-N in wheat shoots. Soluble-N concentration showed decreases at any chloride saline level as compared with the non-saline control. Sulphate salinity caused slight increases in the concentration of protein-N, and slight decreases in that of soluble-N, but did not change that of total-N.

Salt hardening of seeds under both types of salinity tended in general to increase the concentration of protein-N, and total-N. The concentration of soluble-N showed decreases under chloride salinity, whereas tended to increase under sulphate salinity.

Table 4

Effect of chloride and sulphate types of salinity and salt hardening of seeds on nitrogen fraction contents in shoot of wheat seedlings (mg/g dry wt.)

EC of 1 : 5 soil—water ext., mmhos/cm	Hardening of seeds*	Chloride salinity			Sulphate salinity		
		Protein-N	Soluble-N	Total-N	Protein-N	Soluble-N	Total-N
3.5	—	36.9	11.7	48.6	40.33	11.24	51.57
	+	41.0	11.8	52.8	42.40	10.80	53.20
4.5	—	38.2	8.6	46.8	40.43	8.70	49.13
	+	45.9	8.3	54.2	43.28	9.29	52.57
5.5	—	39.7	9.6	49.3	42.62	8.14	50.76
	+	40.6	7.7	48.3	44.12	9.22	53.34
6.5	—	47.9	9.8	57.7	43.17	8.26	51.43
	+	50.7	9.4	60.1	46.59	8.98	55.57
LSD 0.05		2.4	0.7	2.1	0.54	0.85	2.31

* See Table 2.

The recorded tendency for increasing the concentration of protein-N and decreasing that of soluble-N under high levels of both chloride and sulphate salinity was mentioned by STROGONOV (1962) on cotton.

Content of P, Ca, K and Na in shoot. Data in Table 5 show that under chloride saline conditions the concentrations of phosphorus and calcium in the shoot of wheat seedlings were not greatly different from that of the control. Under such conditions, the concentration of potassium markedly decreased, whereas that of sodium markedly increased. Presowing salt hardening of seeds with boric acid could to some extent increase the concentration of potassium, but in the meantime, decrease that of sodium in the wheat shoot as compared with the unhardened seedlings.

Sulphate salinity at 5.5 mmhos level caused decreases in the concentration of both phosphorus and potassium, while markedly increased that of sodium in the shoots of wheat seedlings. The concentration of calcium showed insignificant decreases due to sulphate salinity treatments. Presowing seed treatment with $MgSO_4$ seemed, in general, not able to counteract the disturbances occurring in the concentration of minerals in the shoot of wheat seedlings as compared with water soaked seeds.

Other investigators also found a higher amount of sodium and a lower amount of potassium in the leaves of salt-affected plants regardless of the type of salinity (HENCKEL—SOLOVYOV 1968, STROGONOV *et al.* 1970). In the present experiment the concentration of sodium in chloride salt-affected wheat plants was much higher than that in sulphate salt-affected ones. This result is in harmony with that obtained by HASSON-PORATH *et al.* (1972) with peas.

From the obtained results it seems that chloride salinity has a more inhibitory effect than sulphate salinity on the germination capacity, metabolism and growth of wheat seedlings. Presowing salt hardening of seeds, especially with boric acid under chloride saline conditions

Table 5

Effect of chloride and sulphate types of salinity and salt hardening of seeds on phosphorus, calcium, potassium and sodium contents in shoot of wheat seedlings (mg/g dry wt.)

EC of 1 : 5 soil—water ext., mmhos/cm	Hardening of seeds*	Chloride salinity				Sulphate salinity			
		P	Ca	K	Na	P	Ca	K	Na
3.5	—	2.31	18.99	41.20	4.68	2.55	18.00	39.89	4.25
	+	2.33	17.91	41.09	4.87	2.56	19.80	40.75	3.81
4.5	—	2.25	19.05	33.33	9.71	2.46	16.95	38.84	4.86
	+	2.25	17.56	35.41	6.91	2.51	18.57	38.64	4.48
5.5	—	2.19	18.30	34.58	9.78	2.23	16.78	38.28	5.90
	+	2.21	16.34	37.32	7.26	2.47	18.23	37.71	6.99
6.5	—	2.15	18.30	33.89	10.15	1.90	16.80	32.73	7.31
	+	2.07	17.56	36.52	7.74	2.04	15.88	34.61	6.59
LSD 0.05		N.S.	N.S.	1.94	0.33	0.24	1.86	1.87	0.77

* See Table 2.

seems to be an effective method for increasing both the germination capacity of seeds and the salt tolerance of the developed seedlings.

*

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LIGHT ENERGY TRANSFORMATION IN MAIZE HYBRIDS

The present paper gives an account of studies performed in 1974 at the integrated agricultural establishment at Bábolna (Bábolnai Mezőgazdasági Kombinát) on solar energy transformation (hereafter efficiency) in the maize hybrids OSSK-218 and Dekalb XL-342 grown in Hungary. The following varieties were grown on the experimental area:

OSSK-218, a Yugoslav hybrid maize, FAO number 460; licensed for trade in 1970. It is a two-line hybrid produced by crossing two inbred lines. Its stalk is dark green, medium thick, and does not develop off-shoots. The leaves are dark green, broad and lanceolate. The tassel is loose, medium large; the colour of the anthers is green. With wider spacing it tends to develop two ears. The peduncle is long, therefore the ear when ripening stands away from the stalk. The ear is cylindrical, the grain flat and yellow. The cob is red. The ratio of grain to cob is 84 : 16. Its vegetation period is 145—148 days. It is a midseason variety maturing towards the end of September. Its stalk is firm and thus suitable for mechanical harvesting. The variety is somewhat susceptible to infection by common smut, head smut and the European corn borer, but resistant to Fusarium. It was produced in 1974 on the Bólyi State Farm. At Bábolna it has already yielded 85 q/ha grain (shelled in May).

Dekalb XL-342 is an American hybrid maize, FAO number 580. It is a variety licensed for trade. It was produced in the United States and in Italy. It is a three-line hybrid produced by crossing three inbred lines. It is a very tall plant (270—300 cm) with a thick, dark green stalk and broad, dark green leaves; off-shoots do not develop. The single, long, thick ear always grows at the same height. The ear is cylindrical with a medium long stem. The ears are amply covered by husks. The grain is of dent corn type, flat and broad, and of a pale yellow colour. The grain/cob ratio is 84 : 16. Vegetation takes 156—160 days. It is a late variety of excellent productivity. As to stalk firmness, it exceeds by far the best Hungarian hybrid. It is resistant to diseases, not susceptible to damage done by the European corn borer. Its optimum stand density is 46—50,000 plants/ha. In favourable crop years the largest yields were obtained at Bábolna with this plant number. The seed sown in 1974 was produced in Italy.

On the maize area of the Bábolna Farm large-scale maize production is carried out in a monoculture. Since 1960 weed control on the maize crops has been carried out using chemicals (Table 1).

Table 1

Important farm data

Hybrid	Place and number of maize field	Years of successive maize production	Herbicide	Sowing time	Plant number	Yield* average, q/ha
OSSK-218	B 8 É	9	Eradicane	15—23 April	62,000	64.6
	B 8 NÉ	9	Oleo-Hungazin			
	B 4 É	15	Eradicane			
	B 17 É	3	Satecid 65WP			
DKXL-342	Ba 15 É	4	Aktikon PK	22—23 April	58,000	79.8
	Ba 15 NÉ	4				
	B 22 É	6	Hungazin PK	13 April	68,000	75.3
	B 22 NÉ					

B = Bábolna, Ba = Bana, É = burned, NÉ = not burned.
* Maize in the ear.

The large quantity of maize stalk left on the ground after harvesting can only be chopped up and worked in effectively by repeated disking. To facilitate deep ploughing in the autumn, which is favourable to yield stability, experimental stubble burning was carried out, depending on the weather. Burning destroys some 25—30 per cent of the foliage and stalks. The efficiency studies were performed in both burnt and unburnt fields.

In order to characterize the soil conditions, the results of analysis on samples taken on 22nd May 1974 are presented in Table 2. Meteorological data on the vegetation period, based on observations made at Bábolna, are given in Table 3. Five weeks after sowing — on 22nd May — the varieties were at the four-leaf stage; information about flowering can be obtained from Table 4.

Method of sampling: on each occasion — 22nd May, 5th and 19th June, 3rd, 18th and 31st July and 15th August — 10 and 5 plants were cut for the analyses. The plant dry weight

Table 2

Results of soil analysis

Place and number of maize field	pH		Readily soluble					Calcium carbonate	Arany's compactness number
	water	KCl	y_1	Humus, %	P_2O_5	K_2O	Total N		
B 8 É	7.50	7.45	2.00	8.58	43.5	28.0	0.23	4.71	41.4
B 8 NÉ	7.35	7.20	3.50	6.35	22.5	10.8	0.18	0.12	33.8
B 4 É	7.15	7.10	3.25	6.08	8.1	12.4	0.17	0.20	37.8
B 17 É	7.60	7.60	1.25	6.62	8.6	9.2	0.21	4.12	41.6
Ba 15 É	7.20	7.50	2.00	6.51	8.8	14.4	0.17	0.08	39.4
Ba 15 NÉ	7.60	7.60	1.50	5.29	12.8	11.2	0.19	5.98	39.0
B 22 É	7.40	7.40	2.00	5.88	34.0	20.6	0.15	0.58	30.6
B 22 NÉ	7.50	7.25	3.00	7.84	138.0	74.4	0.24	0.42	38.4

Table 3

Meteorological data (Bábolna 1974)

Month	Average temperature (°C)	Precipitation (mm)	Hours of sunshine (h)
March	7.7	5.1	—
April	11.0	28.9	—
May	14.6	76.4	75*
June	17.6	73.9	184
July	20.3	36.3	208
August	22.4	95.3	214

* Recorded from 21st May onwards.

Table 4

Development of stands
(31st July 1974)

Hybrid	Place and number of maize field	Tasseling, %	Flowering, %	Average height, cm	
				24.7.74	15.8.74
OSSK-218	B 8 É	100	95	193	225
	B 8 NÉ	90	75	180	227
	B 4 É	75	60	158	210
	B 17 É	95	75	180	230
DKXL-342	Ba 15 É	15	—	183	250
	Ba 15 NÉ	5	—	175	244
	Ba 22 É	60	40	180	260
	Ba 22 NÉ	30	10	184	240

and the length and maximum width of the leaves were determined in the laboratory. The averages were used in the calculations. Parts below the soil were not weighed.

Method of evaluation: In determining the leaf area (LA) the formula: length (mm) × width (mm) × 0.74 was used, which gave the leaf area in mm². The 0.74 multiplier was obtained on the basis of samples, and is within the limits given in the literature (KVET—MARSHALL 1971).

To describe the increase in weight and LA we applied the formula $A_1 = A_0 e^{kt}$, where A_0 and A_1 represent the weight or LA at the times t_0 and t_1 respectively, k is the relative growth rate (RGR):

$$k = \frac{\ln (A_1/A_0)}{t_1 - t_0} \qquad \text{and} \quad t = t_1 - t_0$$

(BRIGGS *et al.* 1920, BRODY 1945, KVET *et al.* 1971, ONDOK 1971).

Knowing the RGR we were able to assess the growth of weight and leaf area for any day between two occasions of sampling.

The number of calories incoming by radiation was calculated using the formula:

$$Q = (0.22 + 0.52\, n/N)Q_0$$

where n = the daily hours of sunshine, N = the maximum possible hours of sunshine, Q_0 = the value of global radiation at the outer border of the atmosphere, Q = total incoming calories (cal./cm²/day [MITSUDERA—SAKAI 1975]; the coefficient and constant in the formula published by DURAND [1974] hardly differ from the values given in Mitsudera—Sakai's publication. The values presented by the latter authors agree with the average of those listed in Durand's first table). Since data on the hours of sunshine were available for each day during the period of investigation the value of Q was determined for each day and half of it was used in calculating the efficiency, since about half of the incident light falls within the range of wave-length (PAR) utilized by the plants.

The efficiency was calculated in the following way: we calculated the amount of energy reaching the LA at t_0, the weight increases between t_1 and t_0 (one day) and multiplied it by 4.00 (assessment of the calorific value of dry matter, cal./g dry matter). The growth of the plant

Table 5

Efficiency of maize hybrids (%)

Hybrid	OSSK-218				DKXL-342			
Place and No. of field	B 8 É	B 8 NÉ	B 4 É	B 17 É	Ba 15 É	Ba 15 NÉ	B 22 É	B 22 NÉ
22.5— 4.6	2.18	0.92	1.27	1.19	1.89	1.84	1.75	2.08
5.6—18.6	2.45	2.71	1.51	2.21	1.80	1.66	2.27	1.70
19.6— 2.7	2.90	2.13	2.66	2.21	2.75	2.98	2.57	2.23
3.7—17.7	3.59	4.38	4.52	4.16	2.40	3.97	3.20	3.17
18.7—30.7	1.31	1.81	1.82	1.23	2.30	1.61	1.44	1.93
31.7—15.8	2.57	2.35	1.83	2.33	0.76	1.57	1.23	1.83
Average	2.50	2.38	2.26	2.22	1.98	2.27	2.07	2.15

expressed in calories divided by the PAR number of calories reaching the LA and multiplied by 100 gives the percentage efficiency.

On the basis of efficiency percentage calculated for each day we determined the averages for the periods between two occasions of sample taking (approx. two weeks; Table 5).

The efficiency percentages range within a relatively narrow interval; for the whole table it is 3.76 per cent. With one exception (DKXL Ba 15 É) the highest values occurred between 3rd and 17th July. When calculating the average for the whole period of investigation (last row in Table 5) the range of fluctuation will be still smaller. The hybrids show about the same percentage of average utilization. The average of the total number of data is 2.23%.

There are, naturally, periods when one hybrid shows a higher efficiency than the other. Information on the minima and maxima for the hybrids can be obtained from Table 6 on the

Table 6

Minimum and maximum efficiency of maize hybrids (%)

Hybrid	Number and place of maize field	Minimum		Maximum	
OSSK-218	B 8 É	0.55	(25.7)*	6.47	(12.7)
	B 8 NÉ	0.57	(4.6)	8.38	(12.7)
	B 4 É	0.49	(4.6)	8.66	(12.7)
	B 17 É	0.66	(4.6)	7.97	(12.7)
DKXL-342	Ba 15 É	0.57	(6. and 7.8)	5.06	(30.6)
	Ba 15 NÉ	0.90	(9.6)	7.65	(12.7)
	B 22 É	0.92	(7.8)	6.06	(12.7)
	B 22 NÉ	0.91	(9. and 19.6)	6.05	(12.7)

* Day of occurrence.

basis of daily data. The minima range from 0.5 to 0.9%, and the maxima from 6 to 8.6%. ALESSI—POWER (1975) reported a maximum of 3% for the hybrid 85-Rm in the case of 74,000 plants/ha. It is conspicuous in Table 6 that with the exception of a single case, the maxima all occurred on 12th July. This can be explained by the fact that the weight increase at that time is still considerable; on the other hand, on 11th July the irradiation energy was very low. Efficiency is modified by a number of ecological and physiological factors. Some of these factors can be genetically determined, e.g. the leaf angle, the assimilating capacity, etc. Although these factors were not included in our investigations, the necessity of studying them should be pointed out. Leaf area and leaf angle greatly influence the efficiency. The growth of the leaf area causes an exponential change in the extinction coefficient of PAR (NIČIPOROVIČ 1970). Attention was called to the importance of the leaf angle by LOOMIS *et al.* (1968) and VIDOVIČ (1974). The influence of stand density can also be added to the two factors mentioned (USTENKO—YAGNOVA 1966, ALESSI—POWER 1975). Very little is known about the extent of energy fixation in the shoot.

The calorific content of the different plant organs varies during ontogenesis. The cal./DM value of 4.0—4.4, taken as an average, is only the result of a rough estimation (MÁTHÉ—PRÉCSÉNYI 1971). Detailed investigation data (on stalk, leaf, ear, root) are hardly to be found. Studies on physiological processes require the co-operation of physiologists.

According to LOOMIS *et al.* (1971) the photosynthetic efficiency can be improved by producing new varieties possessing a high photosynthetic potential in a specific environment, as well as by applying appropriate growth regulators besides the necessary cultural practices. Their joint action may increase the production of agricultural crops.

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*

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DETERMINATION OF MATURITY IN LE CONTE, SHOUBRA AND PINEAPPLE PEAR VARIETIES

This investigation was made with the hope of studying the criteria of maturity and its indices for Le Conte, Shoubra and Pineapple pear varieties. Such a study might be helpful in forecasting the exact time of maturity and marketability.

Bagdadi (1955), working on Le Conte pear fruits, concluded that the weight and volume of the pears increased rapidly during July. The rate of this increase was lower during June, May and August, in this order.

Westwood (1962) found that the specific gravity of several varieties of pear, apple and peach was higher at an early growth stage than at any subsequent time.

El-Azzouni—Wali (1957a) reported that the fruits of clonal Le Conte showed less flesh firmness at maturity (10.75 Lbs per sq. in.), while fruits on Baladi quince showed the highest firmness (13—16 Lbs per sq. in.). They also added that the skin colour of both clonal Le Conte and Le Conte budded on different rootstocks was generally citron green 763/2 at maturity.

Magness (1920) found that in Bartlett pears the content of total soluble solids increased steadily with the increase in sugars, from the beginning to the end of the season.

Higazey (1951) and Allen (1942) found that the acidity content decreased during the development of the pear fruits.

This study was carried out on 20 Le Conte, 5 Shoubra and 5 Pineapple pear trees, budded on P. communis rootstocks during the two seasons 1966 and 1967. The trees are cultivated in the orchard of the Faculty of Agriculture, Cairo University. The trees selected were disease-free, uniform in shape and size, in good physical condition and were subjected to the same agriculture practices.

Samples were first taken at two-week intervals, but this was later shortened to one-week intervals. As the fruit samples, each consisting of 15 fruits, reached the laboratory, they were washed, dried and then tested from a physical and chemical point of view.

Prior to the postulated maturity stage, a sample of 30 fruits of each of the varieties studied was picked every week from age 117—145, 96—117 and 110—138 days for Le Conte, Shoubra, and Pineapple respectively. They were then washed, dried, packed in boxes and stored at room temperature (18—20°C). A sample of 10 fruits was drawn after storage for 5 and 10

days from every age and variety for physical and chemical analysis, in order to determine the proper age of maturity.

The physical analysis covered fruit weight, volume, dimensions, firmness, specific gravity and skin colour, while the chemical analysis covered the T. S. S. (total soluble solids), total acidity and total sugar content. The Official Methods of Analysis (A. O. A. C. 1960) were used to measure these characters. The horticultural colour chart issued by the British Council was used to assist in classifying the average colour of the skin of each sample. Table 1 gives the various colours used as standards and the symbols referring to them.

Table 1

Colours and their symbols

Symbol	Criterion	
I	Agathia green	60/1
II	Agathia green	60/2
III	Pea green	61/1
IV	Pea green	61/2
V	Sap green	62/1
VI	Sap green	62/2
VII	Dresden green	64/2
VIII	Dresden green	64/3

It is clear from Tables 2, 3 and 4 that there was a gradual trend of increase in fruit weight and volume in the three pear varieties, with the advancement of the two growth seasons of 1966 and 1967. The rate of increase was higher in Pineapple, moderate in Le Conte, and lower in Shoubra. These results are in agreement with those of EL-AZZOUNI—WALI (1957b), HIGAZEY (1951) and BAGDADI (1955).

It is obvious from Tables 2, 3 and 4 that the specific gravity tended almost to decrease in the three varieties studied, until the maturity stage. During the ripening stages it remained nearly constant until the end of the season, excluding some slight fluctuations. These results agree with WESTWOOD (1962) and BLANPIED (1966).

It can be seen from Tables 2, 3 and 4, that both the equatorial and axial diameters showed a similar trend to that of the weight and volume. On the other hand, the fruit firmness of the varieties studied showed an opposite trend, as it exhibited a gradual decrease as the season advanced. The trend of decrease was higher in Shoubra and moderate in Le Conte and Pineapple. These data agree with WESTWOOD (1962) and EL-AZZOUNI—WALI (1957a).

Tables 2, 3 and 4 illustrate that there was a gradual improvement in the skin colour of the three varieties investigated as the season advanced.

It is clear from Tables 2, 3 and 4 that there was a gradual increase in the total soluble solids, total sugar content, and T. S. S./acid ratio as the season advanced, while a gradual decrease was observed in the total acidity of the three pear varieties during the two seasons 1966 and 1967. These results agree with EL-AZZOUNI—WALI (1957a), HIGAZEY (1951) and ALLEN (1942).

Storage data and the above results showed that the best time for picking the three pear varieties was 131—138, 103—110 and 124—131 days from full bloom for Le Conte, Shoubra and Pineapple respectively. At these dates the fruits showed good appearance and

Table 2

Physical and chemical changes in Le Conte pear

Age, days	Weight, g		Volume, cc		Specific gravity, cm		Equatorial diameter, cm		Axial diameter, cm	
	1966	1967	1966	1967	1966	1967	1966	1967	1966	1967
75	31.9	48.0	31.1	46	1.03	1.04	3.4	4.1	4.7	5.3
89	34.3	66.0	34.3	64	1.00	1.03	3.6	4.6	5.0	6.2
96	67.4	78.0	70.0	71	1.04	1.10	4.6	4.9	5.9	6.4
103	82.6	98.3	80.0	104	1.03	0.95	4.6	5.5	6.0	6.8
110	86.3	103.0	85.0	102	1.02	1.01	5.2	5.6	6.7	6.9
116	90.7	106.4	90.0	99	1.01	1.08	5.1	5.6	7.1	7.2
124	125.9	118.7	125.0	119	1.01	1.00	6.1	5.9	7.6	7.3
131	149.3	165.1	149.0	155	1.00	1.07	6.3	6.3	7.9	7.5
138	149.8	170.5	149.5	163	1.00	1.05	6.2	6.5	7.8	8.3
145	149.8	171.0	149.8	163	1.00	1.05	6.4	6.6	7.9	8.2

Table 3

Physical and chemical changes in Shoubra pear

Age, days	Weight, g		Volume, cc		Specific gravity, cm		Equatorial diameter, cm		Axial diameter, cm	
	1966	1967	1966	1967	1966	1967	1966	1967	1966	1967
75	20.9	19.0	19.0	17.0	1.10	1.11	3.3	3.2	3.6	3.5
89	27.5	27.0	27.6	25.0	1.00	1.08	3.6	3.6	4.0	4.0
96	44.5	40.0	43.0	37.0	1.03	1.08	4.0	3.8	4.5	4.6
103	51.6	45.0	51.5	42.0	1.00	1.07	4.5	4.3	4.9	4.5
110	52.5	67.0	51.0	62.0	1.03	1.08	4.6	5.1	5.6	5.4
117	53.0	76.0	51.6	75.0	1.03	1.01	4.7	5.4	5.4	5.9
124	54.2	78.3	53.0	76.2	1.02	1.03	5.0	5.4	5.6	6.0

Table 4

Physical and chemical changes in Pineapple pear

Age, days	Weight, g		Volume, cc		Specific gravity, cm		Equatorial diameter, cm		Axial diameter, cm	
	1966	1967	1966	1967	1966	1967	1966	1967	1966	1967
75	37.4	66.7	36.9	67	1.01	1.01	4.0	4.7	3.7	4.9
89	58.0	99.0	54.7	96	1.06	1.02	4.5	5.5	4.6	5.9
96	80.8	118.0	74.3	114	1.02	1.04	5.0	6.1	5.3	6.0
103	88.5	119.8	84.7	135	1.04	1.13	5.4	6.2	5.5	6.3
110	127.5	144.8	105.5	137	1.02	1.06	5.9	6.4	6.1	6.8
117	145.5	149.8	140.5	145	1.04	1.03	6.1	6.5	6.0	6.7
124	177.0	182.0	170.0	180	1.05	1.01	6.2	6.7	6.2	6.8
131	182.6	199.2	176.2	182	1.04	1.10	6.4	6.9	7.4	7.6
138	186.8	204.0	181.0	200	1.04	1.02	7.5	7.5	7.6	7.8

fruits during the two seasons 1966 and 1967

Firmness, Lbs. per sq. in.		Colour		T.S.S., %		Acidity, %		Total sugar, %	
1966	1967	1966	1967	1966	1967	1966	1967	1966	1967
15.0	19.0	2.0	2.0	9.8	9.5	0.39	0.38	3.0	3.6
13.9	16.0	2.0	3.0	10.5	9.6	0.34	0.35	3.3	4.3
12.5	14.5	3.0	3.0	10.8	10.3	0.29	0.30	3.9	4.8
11.9	12.9	3.0	3.0	11.0	11.2	0.28	0.29	4.5	5.5
11.5	12.4	3.0	3.0	11.5	12.1	0.26	0.28	4.9	5.8
11.4	11.6	3.0	3.0	12.0	12.5	0.25	0.26	5.5	6.6
10.7	11.3	4.0	4.0	12.8	12.8	0.25	0.25	6.4	7.3
9.7	10.5	4.0	4.0	13.0	13.0	0.23	0.23	6.9	7.9
9.4	9.0	4.0	4.0	13.5	13.5	0.19	0.18	7.8	8.2
8.8	8.6	4.0	4.0	13.6	13.7	0.18	0.18	8.3	8.7

fruits during the two seasons 1966 and 1967

Firmness, Lbs. per sq. in.		Colour		T.S.S., %		Acidity, %		Total sugar, %	
1966	1967	1966	1967	1966	1967	1966	1967	1966	1967
12.5	14.0	2.0	2.0	10.7	10.5	0.22	0.23	4.3	4.0
10.5	13.5	3.0	3.0	11.0	11.0	0.20	0.20	5.0	5.0
9.6	10.2	5.0	5.0	11.0	11.3	0.20	0.19	6.6	6.5
6.2	9.0	6.6	6.6	12.3	11.6	0.19	0.17	7.9	7.8
6.0	6.5	7.0	7.0	12.9	11.8	0.15	0.17	8.6	8.6
5.3	6.5	7.0	7.0	13.4	12.0	0.15	0.15	9.8	9.2
4.5	6.3	8.0	8.0	13.5	12.0	0.15	0.15	10.5	10.3

fruits during the two seasons 1966 and 1967

Firmness, Lbs. per sq. in.		Colour		T.S.S., %		Acidity, %		Total sugar, %	
1966	1967	1966	1967	1966	1967	1966	1967	1966	1967
19.0	19.0	2.0	2.0	9.5	9.5	0.49	0.47	4.1	4.0
17.2	17.9	3.0	3.0	10.3	10.0	0.34	0.38	5.2	4.7
14.2	14.5	4.0	4.0	10.3	10.5	0.31	0.34	6.1	5.9
13.9	14.0	5.0	5.0	11.7	11.0	0.28	0.31	7.0	6.8
13.5	13.8	6.0	6.0	12.0	11.5	0.26	0.30	8.0	7.9
13.0	11.7	6.0	6.0	12.5	12.0	0.27	0.29	8.9	8.3
11.2	10.0	6.0	7.7	12.4	12.2	0.25	0.28	9.8	9.8
10.9	9.7	7.0	7.0	12.7	12.7	0.23	0.22	10.8	10.5
9.8	8.0	7.0	7.0	13.0	13.5	0.19	0.18	11.3	11.3

better quality, and the flesh firmness remained more or less constant. The fruits also showed no shrinkage and exhibited an excellent fruit taste and good appearance of colour. The acidity remained fairly constant with a slight decrease, while a distinct gradual increase in the total soluble solids occurred, allowing the fruits to reach a satisfactory, ripe eating quality.

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FIELD APPLICATION OF SOIL GRANULAR INSECTICIDES FOR THE CONTROL OF THE COTTON LEAFWORM IN EGYPT

The cotton leafworm *Spodoptera littoralis* (Boisd.) was considered to be one of the most serious pests that constitute a major part of the pest complex in cotton in Egypt. Foliar application was the generally accepted means of chemical control of this pest (El-Khishin—Zeid 1957, 1962, Kamel *et al.* 1964, Kamel—Moustafa 1968). Recently, because of restrictions on the foliage application of insecticides, it has become necessary to find alternative methods. Very limited work was carried out concerning the evaluation of granular insecticides either against the larvae or the pupae of this pest. More recently work was started by Abo-Elghar—Radwan (1974), who tested certain promising insecticides as granular formulations against the cotton leafworm under laboratory conditions. The results obtained emphasize that the most effective soil insecticides are those which possess moderately fumigant activity besides contact action.

During the last decade, intensive laboratory and field studies were carried out all over the world for testing various granular soil insecticides against phytophagous insects such as lepidopterous larvae (Begg—Harris 1959, Hofmaster—Dunton 1961, Shorey 1963,

HOFMASTER *et al.* 1967, SHOREY—HALE 1967, HARRIS—SVEC 1968, 1970, HARRIS *et al.* 1968, 1971, HARRIS—HITCHON 1970, HALE—SHOREY 1972).

The present work represents the first field trial in Egypt for controlling the cotton leafworm through soil application with granular insecticides. The main advantages which encouraged us towards such an approach are that it offers a way of eliminating the harmful effects of pesticides on both mammals and beneficial insects, such as predators, parasites, honey bees and domestic animals.

Field experiments were conducted at Salaka, Menofia governorate, to evaluate the efficiency of certain granular soil insecticides for the control of cotton leafworm in cotton. The chosen area was 33.6 hectares divided into plots of approximately 0.63 hectares each.

The experiment consisted of 19 treatments: 3 insecticides, 2 rates of application, 3 schedules and 1 untreated check, each replicated three times in a complete randomized block design.

Insecticides formulated as granules of 5 per cent Chlorpyrifos, Disulfoton and 10 per cent Cyolane were applied as soil surface treatments. Each insecticide was investigated at 2 rates of kg actual toxicant per hectare as follows: (1) Chlorpyrifos at 1.19 and 1.79; (2) Disulfoton at 2.98 and 3.57; (3) Cyolane at 0.95 and 1.19. Insecticides were applied twice for each treatment during the cotton growing season. The first application started on June 20, July 3 and July 16 for the three tested schedules respectively. The second application for the same tested schedules was carried out at a uniform date on 3rd August. Due to lack of Cyolane and Disulfoton quantities, plots of moderate and late schedules were applied Chlorpyrifos at rates of 23.81 and 35.71 kg in the second application. All plots were irrigated uniformly as soon as granules were sown.

The efficiency of the tested insecticides was assessed on the basis of the insecticide potency in the suppression of the cotton leafworm infestation level. The insect infestation level was estimated according to three different population indexes. The first is concerned with the larval population, where the mixed larval population on 100 randomly chosen plants was counted weekly beginning 24th June to 1st. Sept. At each count larvae were differentiated into two groups, i.e. the first included the smaller instars (1—3), the second involved the bigger instars (4—6). The second population index is concerned with pupae where the soil of 929.01 cm^2 under each of previously inspected plants was examined to a depth of 5.08 cm. Egg masses were collected by hand at 3 days intervals from each treatment and were calculated per hectare to be used as the third population index.

Results in Table 1 clearly indicate that the early date of application (20th June) seemed to represent the proper time where the average reduction in number of egg masses recorded was 12.4 and 57.5 per cent at lower and higher rates of tested materials respectively. On the other hand, late application (16th July) showed the least reduction. As regards the potency of the tested products, Cyolane induced the best performance showing 29.2 and 85.3 per cent reduction in the number of egg masses when applied early (20th June) at the rates of 0.95 and 1.19 kg Al/hectare respectively. All other materials were less effective. The same ranking could be observed in the other two schedules.

The effectiveness of soil application with granular insecticides on the larval instars of the cotton leafworm is represented in Table 2. It is evident that the second schedule (July 3) seemed to represent the proper time for granule application as it induced the best results against the larval instars, showing averages of 49.4 and 75.8 per cent reduction at the lower and higher rates of application respectively. On the other hand, the late schedule (16th July) resulted in the least effect. It is of interest to note that the natural population density of the different developmental stages of the cotton leafworm during the second schedule (3rd July—1st August) seems to be well presented by both larvae and pupae (Fig. 1); the larval population attained its maximum peak and the pupal trend showed a pronounced increase. In addition,

Table 1

Effectiveness of soil application with granular insecticides against the cotton leafworm S. littoralis (Boisd.) on number of egg-masses deposited under field conditions

Insecticides	Rate of application, kg Al/ha	Daily mean number, egg-mass/ha		Per cent reduction of egg-mass number		Average reduction, %
		1st appl.	2nd appl.	1st appl.	2nd appl.	
		1st application at June 20				
Cyolane 10% G	0.95	0.81	1.29	58.5	000	29.2
	1.19	0.57	0.00	70.7	100	85.3
Disulfoton 5% G	2.98	2.05	0.95**	00.0	000	00.0
	3.57	1.21	0.00**	37.8	100	68.9
Chlorpyrifos 5% G	1.19	1.64	3.88	15.8	000	07.9
	1.79	1.24	3.07	36.6	000	18.3
Average*	Lower	1.50	1.95	24.8	000	12.4
	Higher	1.00	1.02	48.4	66.6	57.5
Control	—	1.95	0.48			
		1st application at July 3				
Cyolane 10% G	0.95	1.60	1.79	20.2	000	10.1
	1.19	0.98	0.29	51.2	40	45.6
Disulfoton 5% G	2.98	1.93	1.19**	03.5	000	01.7
	3.57	0.95	0.88**	52.3	000	26.1
Chlorpyrifos 5% G	1.19	1.48	3.52	26.2	000	13.1
	1.79	1.29	3.50	35.7	000	17.8
Average*	Lower	1.67	2.16	16.6	000	08.3
	Higher	1.07	1.07	46.4	13.3	29.8
Control	—	2.00	0.48			
		1st application at July 16				
Cyolane 10% G	0.95	1.29	1.24**	000	000	000
	1.19	0.52	0.60**	57.0	000	28.5
Disulfoton 5% G	2.98	1.81	1.86**	000	000	000
	3.57	0.79	1.19**	35.3	000	17.6
Chlorpyrifos 5% G	1.19	1.81	3.74	000	000	000
	1.79	1.60	3.00	000	000	000
Average*	Lower	1.64	2.29	000	000	000
	Higher	0.98	1.60	30.8	000	15.4
Control	—	1.21	0.48			

* Averages were calculated with the exception of untreated control.
** Chlorpyrifos granular was used for the 2nd application at the indicated treatments.

Table 2

Effectiveness of soil application with granular insecticides on the larval stage of cotton leafworm S. littoralis

Insecticides	Rate of application, kg Al/ha	Average number of larvae/ 100 plants		Reduction, %		Average reduction, %
		1st appl.	2nd appl.	1st appl.	2nd appl.	
		1st application on June 20				
Cyolane 10% G	0.95	26.7	132.0	45.3	000	12.6
	1.19	11.8	43.1	75.9	13.3	44.6
Disulfoton 5% G	2.98	20.2	277.2**	58.5	000	29.2
	3.57	8.9	55.9**	81.7	000	40.8
Chlorpyrifos 5% G	1.19	21.8	57.7	55.3	000	27.6
	1.79	11.7	27.7	76.0	84.5	80.2
Average*	Lower	22.9	155.6	53.0	000	26.5
	Higher	10.8	42.2	77.9	32.6	55.2
Control	—	48.8	49.7			
		1st application on July 3				
Cyolane 10% G	0.95	11.4	77.5	76.0	000	38.0
	1.19	4.4	26.0	91.0	47.7	69.3
Disulfoton 5% G	2.98	10.6	12.0**	78.2	74.8	76.5
	3.57	6.3	9.5**	87.1	80.9	84.0
Chlorpyrifos 5% G	1.19	15.7	71.9	67.8	000	33.9
	1.79	3.4	22.2	93.0	55.3	74.1
Average*	Lower	12.6	53.8	74.0	24.9	49.4
	Higher	4.7	19.2	90.4	61.3	75.8
Control	—	48.8	49.7			
		1st application on July 16				
Cyolane 10% G	0.95	23.7	121.1**	000	000	000
	1.19	18.3	54.6**	000	000	000
Disulfoton 5% G	2.98	22.4	159.4**	000	000	000
	3.57	15.9	27.4**	23.0	44.9	33.9
Chlorpyrifos 5% G	1.19	14.8	39.5	18.5	20.5	19.5
	1.79	3.6	25.1	80.3	49.5	64.9
Average*	Lower	20.3	106.6	6.2	6.8	6.5
	Higher	18.2	35.7	34.4	31.5	32.9
Control	—	18.2	49.7			

* Averages were calculated with the exception of untreated control.
** Chlorpyrifos granular was used for the 2nd application at the indicated treatments.

Table 3

Natural population distribution of different larval instars of the cotton leafworm during cotton growing season of 1973

Sampling date		Average number of mixed larvae/100 plants	Distribution of different larval instars			
			1–3 instars		4–6 instars	
			No.	%	No.	%
June	24	29.0	19.3	71.5	9.7	28.5
July	1	77.6	32.7	42.1	44.9	57.9
	7	106.6	16.8	15.8	89.8	84.2
	14	52.1	12.3	23.6	39.8	76.4
	21	19.7	6.9	35.0	12.8	65.0
	28	16.9	7.8	46.1	9.1	53.9
August	4	45.3	0.9	1.5	44.4	98.5
	11	40.5	27.7	68.6	12.8	31.4
	19	2.4	0.4	20.0	2.0	80.0
	25	51.5	49.9	96.9	1.6	03.1
Sept.	1	131.8	118.1	89.6	13.7	10.4

it is apparent that the majority of the larval population during this period was of the older instars (Table 3) which are the most susceptible to soil insecticides (ABO-ELGHAR—RADWAN 1974). Therefore, it is suggested that the tested granular insecticides could act well throughout this period against both larvae and pupae of the cotton leafworm.

Regarding efficiency of the tested insecticides, it is evident that all materials were effective at variable degrees. The two applications of Chlorpyrifos showed the best performance inducing 27.6, 33.9 and 19.5 per cent reduction at a rate of 1.19 kg Al/hectare compared with an 80.2, 74.1 and 64.9 per cent reduction at a rate of 1.79 kg Al/hectare for the three tested schedules respectively. On the other hand, plots treated with Disulfoton followed by Chlorpyrifos at the middle schedule seemed to surpass all other treatments resulting in a 76.5 and 84.0 per cent reduction at the lower and higher rates respectively. This performance could lead us to the conclusion that the performance of potential soil insecticides could be attributed mainly to one or more of the following factors: (1) the stability of the product in the soil; (2) the product having more than one mode of action; (3) the conditions prevailing throughout the experimental period. Accordingly, the best performance of the treatment with Disulfoton followed by Chlorpyrifos could be attributed to the interaction between the long persistent first application of Disulfoton and Chlorpyrifos having more than one mode of action (ABO-ELGHAR—RADWAN 1974).

Data in Table 4 reveal the value of timing for soil-insect control. Regarding the first application schedules, a remarkable suppression in pupal population could be noticed at the middle schedule (3rd July). Such a finding means that the best results could be arrived at when soil insecticides were applied as the pupal population trend was about to increase (Fig. 1). Considering the cumulative effect of the two applications, the late schedule achieved the best performance due to the short interval between the two applications. As for the tested compounds, all materials induced a satisfactory pronounced reduction in pupal population with a noticeable superiority of Cyolane.

Table 4

Effectiveness of soil application with granular insecticides on the pupal stage of cotton leafworm S. littoralis (Boisd.)

Insecticides	Rate of application, kg Al/ha	Weekly mean number of pupae/10 m²		Pupal reduction, %		Average reduction, %
		1st appl.	2nd appl.	1st appl.	2nd appl.	
1st application at June 20						
Cyolane 10% G	0.95	1.6	5.4	40	82.7	61.3
	1.19	0.5	4.7	80	84.8	82.4
Disulfoton 5% G	2.98	1.6	25.6	40	18.2	29.1
	3.97	0.5	8.1	80	74.1	77.0
Chlorpyrifos 5% G	1.19	0.5	14.8	80	52.7	66.3
	1.79	0.5	11.4	80	63.4	
Average*	Lower	1.3	15.2	53.3	51.2	52.2
	Higher	0.5	8.1	80.0	74.1	77.0
Control	—	2.7	31.3			
1st application at July 3						
Cyolane 10% G	0.95	1.3	7.5	61.3	76.2	68.7
	1.19	0.0	4.7	100.0	84.8	92.4
Disulfoton 5% G	2.98	0.6	26.4	80.6	15.8	48.2
	3.57	0.6	20.2	80.6	35.5	58.0
Chlorpyrifos 5% G	1.19	0.6	18.3	80.6	41.4	61.0
	1.79	0.0	15.6	100.0	50.3	75.1
Average*	Lower	0.9	17.4	74.2	44.5	59.3
	Higher	0.2	13.5	93.5	56.9	75.2
Control	—	3.3	31.3			
1st application at July 16						
Cyolane 10% G	0.95	1.3	10.2	67.5	67.6	67.5
	1.19	0.0	6.0	100.0	80.7	90.3
Disulfoton 5% G	2.98	1.3	14.8	67.5	52.8	60.1
	3.57	1.3	6.0	67.5	80.7	74.1
Chlorpyrifos 5% G	1.19	2.7	12.1	32.4	61.3	46.8
	1.79	0.0	6.0	10.0	80.7	90.3
Average*	Lower	1.7	12.3	55.8	60.6	58.1
	Higher	0.4	6.0	89.2	80.7	84.9
Control	—	4.0	31.3			

* Averages were calculated with the exception of untreated control.

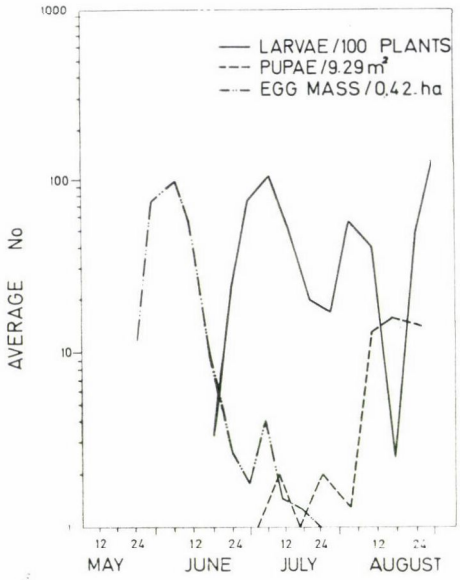

Fig. 1. Seasonal population trends of different developmental stages of the Egyptian cotton leafworm *S. littoralis* (Boisd.) in untreated cotton fields, Menofia Governorator, Egypt 1973

Generally, based on the data presented here, applying granular insecticides as soil surface treatment appears to be promising as an alternative method for the control of the cotton leafworm.

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THE EFFECT OF N-DIMETHYL AMINO SUCCINAMIC ACID ON T HE QUALITY OF BANATI AND GHARIBI GRAPES DURING COLD STORAGE

This investigation aims to study the effect of post harvest treatments with a growth suppressing substance, namely Alar (N-dimethyl amino succinamic acid), on the keeping quality and some characters of Banati and Gharibi grape varieties during cold storage.

Growth of some microorganisms, including penicillium sp., was reduced slightly by Alar at 500 p.p.m., while a higher concentration stopped it completely (LARSER—GROMARLY 1966).

It was mentioned that pre-harvest treatments of apple fruits with Alar retarded fruit ripeness (BATJER 1965). Within the fruit storage period, Alar treatments showed a lower juice percentage and T. S. S./acid ratio, while a lower percentage of decay and total acidity (ABD EL-LATIEF, STINO—ABD EL-LATIEF 1970).

Alar treatment hastened the fruit colouration of apples (EDGERTON—HOFFMAN 1965).

Many workers showed that there was a significant effect of Alar on the titrable acids of apple fruits. In some cases Alar increased the acidity of apples (WILLIAMS *et al.* 1964), while it reduced it in others (LOONEY *et al.* 1967). Alar treatments increased the soluble solids in Italian prunes (PROCBSTING—MILLS 1966), while FISHER—LOONEY (1967) reported that Alar reduced the soluble solids.

This work was carried out in the Fruit Section, Department of Plant Production, Faculty of Agriculture, Cairo University. Full grown Banati and Gharibi grape varieties, 20 years old, uniform in growth and in good physical condition, were chosen to obtain the required material. When bunches attained full maturity, due to the indices found by EL-AZZOUNI—EL-MAHDI (1960), they were picked in the morning and then transported immediately to the laboratory. They were sorted to discard the injured ones, well washed with tap water, and well air dried. Before bunches were stored under cold storage conditions at 0°C, they were dipped in concentrations of 500 (T_1), 1000 (T_2), 2500 (T_3), 3000 (T_4) and 6000 (T_5)

Table 1

The effect of different concentrations of Alar on the fruit juice percentage during cold storage at 0°C

Periods of storage, weeks	Banati											
	1972						1973					
	T_1	T_2	T_3	T_4	T_5	T_6	T_1	T_2	T_3	T_4	T_5	T_6
2	70.3	75.7	76.7	71.8	75.0	74.3	72.7	77.0	76.8	72.3	71.0	70.8
4	68.9	73.1	67.7	69.1	70.0	70.3	66.4	73.9	74.5	67.9	66.9	65.1
6	65.8	71.1	63.3	62.4	68.0	66.7	64.9	70.8	69.4	64.7	64.2	62.3
8	60.9	67.6	61.8	62.5	66.0	63.0	62.7	66.4	70.0	61.8	62.6	59.2
10	61.8	65.8	62.5	62.9	64.1	61.8	63.0	68.0	65.7	58.9	59.6	60.1
12	57.1	64.2	62.8	61.3	59.7	60.6	61.4	66.9	64.5	60.9	60.0	60.0
	Gharibi											
2	73.5	72.9	72.0	67.8	70.3	66.3	69.8	70.7	70.8	70.0	64.9	65.6
4	66.3	66.0	65.8	57.4	71.8	67.3	65.3	67.3	65.6	64.2	62.8	62.2
6	63.5	64.0	63.2	59.4	62.2	61.4	62.8	66.2	66.0	61.9	61.2	61.0
8	62.5	65.8	64.0	58.9	60.8	61.0	63.2	65.5	65.1	60.1	59.8	60.6

Table 2

The effect of different concentrations of Alar on fruit loss percentage during cold storage at 0°C

Periods of storage, weeks	Banati											
	1972						1973					
	T_1	T_2	T_3	T_4	T_5	T_6	T_1	T_2	T_3	T_4	T_5	T_6
2	1.50	0.82	1.25	1.39	1.99	2.35	1.42	0.66	0.92	1.86	2.01	2.00
4	2.00	1.14	2.00	2.05	3.12	4.33	2.11	1.16	1.92	1.68	2.86	3.95
6	3.19	2.02	2.67	2.80	3.95	5.91	2.86	1.89	2.80	2.98	3.77	4.38
8	3.91	2.80	3.20	3.62	4.71	7.60	3.66	2.67	3.55	3.51	4.63	5.99
10	4.24	3.20	3.69	4.00	5.22	8.53	4.50	3.25	3.95	3.88	4.98	7.56
12	4.65	3.25	4.15	4.35	5.40	9.85	5.56	4.00	4.50	4.50	6.26	10.0
	Gharibi											
2	2.44	1.05	1.60	2.40	2.06	3.11	1.50	1.22	1.43	1.82	1.89	2.71
4	5.60	2.56	3.68	6.11	6.08	6.80	3.27	2.04	2.91	3.41	3.40	4.44
6	7.34	3.47	5.36	8.73	8.81	9.57	5.00	3.11	4.25	5.26	5.64	6.88
8	9.25	5.50	7.25	10.2	11.5	14.9	6.84	4.66	5.92	7.33	7.68	10.2

p.p.m. of Alar; 50 bunches for each concentration, as well as 50 bunches in distilled water as control (T_6). The treated and the untreated bunches were packed in carton boxes, and then cold stored. Samples were taken every two weeks for physical and chemical analysis, which were carried out according to the Official Method of Analysis (A. O. A. C. 1970).

It can be seen from Table 1 that the juice percentage of all the treated and untreated fruits showed a trend of a gradual decrease with the advance of the storage period of both seasons. At the end of the storage period, most of the treated fruits showed a nearly higher juice percentage than the untreated fruits (control), excluding some fluctuations. Fruits treated with Alar at concentrations of 1000 (T_2) and 2500 (T_3) p.p.m. showed the highest percentage of juice, for both Banati and Gharibi varieties. These results agree with those of ABD EL-LATIEF (1963) on the Banati grape variety, but disagree with the findings of EL-AZZOUNI *et al.* (1972) on Amoun orange, as they reported that the juice percentage of the Alar treated fruits increased gradually with the advancement of the storage period. It is evident from Table 2 that the fruit

Table 3

The effect of different concentrations of Alar on fruit colour changes during cold storage at 0°C

Periods of storage, weeks	Banati											
	1972						1973					
	T_1	T_2	T_3	T_4	T_5	T_6	T_1	T_2	T_3	T_4	T_5	T_6
2	1	2	1	1	1	1	1	2	1	1	1	1
4	3	2	3	2	2	2	2	3	3	2	2	2
6	4	4	4	3	3	3	4	4	4	4	3	3
8	5	5	5	5	4	4	4	5	5	5	4	4
10	5	6	6	5	5	5	5	6	6	6	5	5
12	6	6	6	6	6	5	6	6	6	6	5	6
	Gharibi											
2	1	2	2	1	1	1	2	2	2	1	2	1
4	3	4	3	3	2	2	4	4	4	3	3	3
6	4	5	5	5	3	4	5	5	5	5	4	4
8	6	6	6	6	5	5	6	6	6	6	6	5

Colour		Symbol
Agathia green	60/2	1
Pea green	61/1	2
Pea green	61/2	3
Sap green	62/2	4
Pea green	61/3	5
Uraniun gree	63/2	6

According to the Horticultural Colour Chart issued by the British Colour Council.

loss percentage of all treatments increased gradually with the advancing of the storage period. Besides, it is clearly obvious that all the used concentrations of Alar decreased noticeably the fruit loss percentage compared to the control of both Banati and Gharibi varieties in both seasons.

At the end of the storage period, the least percentage of fruit loss was noticed in the fruits dipped in Alar solution at both 1000 and 2500 p.p.m. for both Banati and Gharibi varieties, during both seasons. Also, it can be noticed from Table 2 that the loss percentage of Gharibi grapes was higher than that of the Banati variety.

Table 3 illustrates that the fruit colour of the treated and the untreated fruits showed an improvement with the progressing of the storage period. The fruit was considered completely coloured when it attained the surface uranium green 63/2 colour. In addition, it seems that there were no noticeable differences between the colour changes of both the treated and the untreated ones, except treatments T_2 and T_3, as, for some reason, they resulted in enhancing the treated fruit colouration compared to the other treatments of both Banati and Gharibi varieties. These results are in harmony with those of EDGERTON—HOFFMAN (1965), who reported that Alar treatment hastened the fruit colouration of apples.

Total soluble solids increased in the juice of fruits during storage (Table 4). Continuous increase in the T.S.S. percentage occurred in all treatments. A smaller degree of increase could be noticed in the untreated than in the treated fruits especially in the last period of Banati and Gharibi storage. This indicates a reduced loss of sugars in the catabolic process of the treated fruits. Besides, it is quite evident that no clear differences could be noticed among the different treatments. But, at the end of the storage period, it could be noticed that T_2 and T_3 exhibited higher T.S.S. values than the other treatments of both Banati and Gharibi varieties. These results agree with those of PROCBSTING—MILLS (1966), as they mentioned that Alar treatments increased the soluble solids in Italian prunes, but disagree with those of FISHER—LOONEY (1967), who reported that Alar reduced the soluble solids of the fruits.

Table 4

The effect of different concentrations of Alar on fruit total soluble solids during storage at 0°C

Periods of storage, weeks	Banati											
	1972						1973					
	T_1	T_2	T_3	T_4	T_5	T_6	T_1	T_2	T_3	T_4	T_5	T_6
2	13.5	15.5	15.5	13.5	13.0	12.5	13.5	15.0	15.5	13.0	12.5	12.0
4	14.0	15.0	16.0	15.5	14.0	14.0	14.0	16.0	15.5	13.5	13.0	13.0
6	14.5	15.5	16.5	15.0	15.0	14.0	15.0	16.0	16.0	14.0	12.5	14.0
8	15.0	16.5	17.0	16.0	15.0	14.0	16.0	16.5	16.5	15.5	14.0	14.5
10	15.5	17.0	17.0	17.0	16.0	14.5	16.0	17.0	17.0	15.5	15.0	15.0
12	16.0	17.0	17.5	17.0	16.0	15.5	16.5	17.0	17.0	16.5	16.0	16.0
	Gharibi											
2	12.5	14.5	14.0	14.5	12.5	12.5	13.5	14.0	14.0	13.5	12.5	13.0
4	14.0	15.0	15.5	15.0	12.5	14.5	15.5	15.0	15.5	14.0	13.5	14.5
6	14.5	16.0	16.0	15.5	14.0	15.0	15.5	16.5	16.0	15.5	15.0	15.0
8	15.5	17.5	17.0	16.5	15.0	15.5	16.0	17.0	17.0	16.0	15.5	15.5

Table 5

The effect of different concentrations of Alar on fruit total acidity during cold storage at 0°C

Periods of storage, weeks	Banati											
	1972						1973					
	T_1	T_2	T_3	T_4	T_5	T_6	T_1	T_2	T_3	T_4	T_5	T_6
2	1.25	0.90	0.89	1.02	1.06	1.18	1.13	0.95	0.78	1.06	1.12	1.18
4	0.74	0.71	0.77	0.80	0.98	0.98	0.90	0.72	0.68	0.89	0.90	0.97
6	1.30	1.29	0.99	1.19	0.99	1.33	1.22	0.99	0.87	1.06	1.21	1.24
8	1.09	1.01	0.81	1.20	1.00	1.24	1.16	0.98	0.80	1.03	1.20	1.21
10	0.98	0.95	0.72	1.10	1.02	1.21	1.14	0.90	0.81	1.03	1.17	1.22
12	1.01	0.97	0.74	1.11	1.05	1.19	1.11	0.91	0.78	1.05	1.13	1.24
	Gharibi											
2	0.58	0.50	0.45	0.60	0.58	0.50	0.52	0.47	0.41	0.58	0.54	0.53
4	0.68	0.59	0.58	0.68	0.66	0.65	0.66	0.54	0.54	0.64	0.62	0.67
6	0.65	0.56	0.46	0.67	0.64	0.60	0.59	0.48	0.46	0.61	0.59	0.61
8	0.66	0.55	0.47	0.63	0.61	0.60	0.57	0.48	0.42	0.58	0.55	0.60

It can be seen from Table 5 that the total acidity of all treatments decreased gradually and continuously as the storage period advanced, until reaching their minimum values at the end of storage period. Also, it is clear that the total acidity of all the Alar treated fruits was lower than that of the control.

Besides, the fruits dipped in concentrations of 1000 (T_2) and 2500 (T_3) p.p.m. Alar showed the lower values of acidity at the end of the storage period followed by the other treatments. So, at the end of the storage period, the control exhibited nearly higher values of total acidity, in both Banati and Gharibi varieties. But, the total acidity of the Gharibi variety was lower than that of the Banati, as it is clear from Table 5. The results of the two seasons were similar. The above results agree with ABD EL-LATIEF (1963) and LOONEY *et al.* (1967), but disagree with WILLIAMS *et al.* (1964), who reported that Alar treatment increased the acidity of apples.

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RESISTANCE INCREASED BY MAGNESIUM NUTRITION

It has been known for a long time that various fertilizers (primarily N, P and K) exercise an influence not only on the quantity and quality of the yield and the time of ripening, but also on the susceptibility and resistance to certain diseases. In plant growing trials carried out with magnesium fertilizers and nitrogen fertilizers supplemented with magnesium (KISS 1969, FEJÉR *et al.* 1972, HORVÁTH *et al.* 1971) we observed not only an increased quantity and quality of yield but also a higher resistance to diseases in various plants. In the case of magnesium nutrition, KEMENESY—NYÉKI (1967) found the virus infection of potato to decrease; the number of virus-infected plants was 73 per cent lower than in the control plots. KLOKE (1963) observed a reduced *Botrytis* and *Phytophthora* infection in tomato plants supplied with magnesium. The same author pointed out that the percentage decrease in infection was influenced not only by the quantity of magnesium applied but also by the variety of the tomato plant.

After such preliminaries we studied the inhibitory effect on infection of magnesium applied both as a basic fertilizer and in the form of a foliage spray, using, among others, sugar-beet (KISS—KISS 1972, KISS 1974a, KISS—RÉDEI 1975) and bean (KISS 1974b) as indicator plants. In our experiments magnesium treatment resulted in a 50—60 per cent inhibition of infection by *Cercospora beticola*, *Pleospora betae* and *Pseudomonas phaseolicola*. The increased disease resistance caused by magnesium belongs — according to HOLMES (1954) — to the category of field resistance. This category includes those cases when the resistance of the host plants is increased by choosing ecological factors (e.g. fertilization, sowing time) which provide them with favourable conditions (NAUMOV—SHCHEGOLEV 1948).

Field resistance may also be considered as ecological resistance although many authors only place the resistance-increasing effect of climatic factors in this category. Having obtained positive results, which are also important from a practical point of view, we tried to find an explanation for the inhibitory (i.e. resistance-increasing) effect of magnesium on infection, of which we have given an account in the present paper.

Except those listed above hardly any literary data are available on the magnesium-induced increase in field resistance, while there is virtually no mention in the literature of the cause of this increased resistance. Starting from our earlier biochemical investigations related to magnesium (KISS 1973, KISS—POZSÁR 1972, 1975, VERMES *et al.* 1974) we have arrived at the conclusion that the cause of increased field resistance must lie in the influence exercised by the magnesium on the nitrogen and/or energy cycle.

This is why — as a preliminary study — we looked at the literature on the relationship between resistance and protein. We have found that in papers discussing the non-genetic resistance of plants more and more is said about the relation of resistance to protein content (and nitrogen fertilization). Some of these papers contain favourable (SCHIMMELPFENG 1963, LANGBEIN—PEHL 1962, VRANY 1972), and some unfavourable (ROUKOLA 1962, CHEN—CHIEN 1964, KIRÁLY 1963) results. The observation that it is the intensity of nucleic acid synthesis rather than the nitrogen level of the soil and the total nitrogen content of the plants that is in negative correlation with the susceptibility to infection has put an end to these contradictions (KIRÁLY *et al.* 1968).

The experiments were carried out on the leaves of two wheat varieties (*Triticum aestivum* L.: Bánkuti 1, Bánkuti 1201), a bean variety (*Phaseolus vulgaris* L.: Pinto), a maize variety (*Zea mays* L.: Mv5) and a commercial lettuce variety (*Lactuca sativa* L.). The primary leaves of rust-infected wheat (*Puccinia graminis* f. sp. *tritici* Ericks) and rust-infected bean (*Uromyces appendiculatus* [Pers] Link) supplied the test material for the pathological examinations.

Of the bioactive compounds the systemic fungicides were studied for their action on primary leaves of the bean variety Pinto by the so-called half-leaf method. For a week the fungicides were applied every day using a brush, then during the second week the leaves were left untreated. Samples were taken and processed on the 14th day.

After the preliminary treatment described above the developmental and pathological examination of the leaf proteins was performed by means of Sephadex G—150 gel chromatography to characterize the fractions by molecular weight. To obtain the quantity of protein the nitrogen content determined with the micro-Kjeldahl method was multiplied by 6.25.

In our experiments on brown spot (*Pleospora betae* Björl) infection in sugar-beet the magnesium was mixed with a nitrogen fertilizer (KISS—RÉDEI 1975). Some of the magnesium was applied before sowing, in combination with AGRONIT (a commercial fertilizer produced by the Borsod Chemical Works containing 28 per cent nitrogen and 2 per cent magnesium), and some — in the case of ammonium nitrate base fertilization — as a foliage spray, in the form of a 2 per cent solution of magnesium sulphate. The active agent level was the same in both cases (1.7 q/ha nitrogen and 12 kg/ha magnesium). The sugar-beet variety Beta poly 2 was artificially inoculated by spraying the plants with an aqueous suspension prepared from dried diseased leaves. The treatments were applied in four replications, partly in a greenhouse (Tables 2, 3, 4) and partly in a microplot field experiment. The soil used in the experiment was a brown forest soil poor in lime and magnesium.

In our experiments on sugar-beet the magnesium treatment — whether it was applied as a base fertilizer or in the form of a foliage spray — decidedly inhibited the infection caused by *Pleospora betae* Björl (Table 1). Information on the inhibition of infection is given by our bean rust infection and other experiments, on a comparable basis.

According to our investigations (POZSÁR *et al.* 1973), resistance to rust infection depends on the concentration of immunobiologically active, low molecular weight proteins rather than on the total protein content. Table 2 presents the resistance to *Uromyces appendiculatus* uredospores of Pinto bean leaves with identical total protein contents, as a function of the molecular weight distribution of the protein fractions. During senescence the high molecular weight fractions increase while those of low molecular weight decrease in the leaves com-

Table 1

Effect of magnesium treatment on the brown spot disease (Pleospora betae Björl) of sugar-beet

Treatment	Percentage of diseased plants	
	9 September	18 September
Control	20.0	29.8
NH_4NO_3	18.0	29.2
AGRONIT 28	3.0	14.9
NH_4NO_3 + Mg	3.0	14.5
Highest deviation from the average	±2.5	±3.4

pared to the initial stage. In the first phase of leaf senescence a 44 and 58 per cent decrease in the proportions of the first and second fractions and a 33 and 52 per cent increase in those of the two middle fractions can be pointed out. In the case of the highest molecular weight fractions the increase in the level is even greater, the difference being 55 and 93 per cent, respectively. The characteristic shifting in the proportions of leaf proteins fractionated by molecular weight in the initial phases of senescence can be brought into correlation with an increased pathological susceptibility, which is also of outstanding importance from a general biological point of view. In rust-infected wheat and bean leaves a change in the proportion of protein fractions similar to that observed in healthy leaves at an advanced stage of senescence can be demonstrated (Table 3).

As a response to infection the lowest molecular weight fractions showed a 37 per cent decrease in rust-infected wheat leaves and a 45 per cent decrease in rust-infected bean leaves, as compared to the healthy control. At the same time the proportion of higher molecular weight protein fractions characteristically increased under the influence of infection. The individual fractions also contain proteins from the mycelia of infectious fungi, which suggests that the proportional change in the fractions in the host organism may be even greater than that shown

Table 2

Relationship between the age of Pinto bean leaves and the percentage proportion of protein fractions in them and the related susceptibility to infection by Uromyces appendiculatus

Age of leaves, days	Percentage distribution of protein fractions by molecular weight (1000 x)					Susceptibility of leaves to infection
	12	24	36	120	400	
4	17.5	28.1	23.7	24.6	6.0	none
8	16.6	23.7	23.7	29.9	6.1	very low
12	15.0	19.5	26.0	33.7	5.8	low
16	12.0	14.9	27.7	33.7	11.7	high
20	10.1	11.6	31.5	37.5	9.3	very high
Percentage change in 16 days	−44	−58	+33	+52	+55	

Table 3

Effect of infection on the percentage distribution of different molecular weight leaf protein fractions in the wheat variety Bánkuti 1201 and the bean variety Pinto examined in the sporulation phase

Molecular weight of fractions (1000 x)	Bánkuti wheat			Pinto bean		
	Healthy	*P. graminis* infection	Percentage change in fractions	Healthy	*U. appendic.* infection	Percentage change in fractions
12	16.0	10.1	−37	19.5	10.6	−45
24	13.1	8.1	−38	15.0	13.4	−10
36	28.2	37.7	+34	26.0	30.2	+16
120	32.2	33.7	+3	33.7	35.5	+6
400	10.5	10.4	−1	5.8	10.3	+77

by the measurements. As a result of the intensive protein synthesis it is, in fact, the amount of low molecular weight fractions that first increases in the parasites. It follows from the above that in any plant hormones and bioactive compounds that induce protein fractions ratios characteristic of the juvenile stage can be regarded at the same time as resistance factors. It may be supposed that the characteristic increase in the level of low molecular weight (soluble) protein fractions is in positive correlation with the immunologically active fractions. The latter is part of the indirect evidence for the pathological influence exercised on the plants by the bioactive compounds (systemic fungicides). To confirm the hypothesis we studied the effect of several systemic fungicides, which induce resistance, on protein synthesis and on the ratio of the protein fractions. The data in Table 4 (POZSÁR *et al.* 1973) show that these fungicides induce rejuvenescence by increasing the proportion of low molecular weight (soluble) protein fractions.

After this we examined the effect of magnesium on plant protein formation. According to our data the protein level of the plants rises whenever magnesium fertilizer is applied. Table 5 shows the change in the soluble protein contents in wheat, maize and bean leaves as a response to magnesium nutrition (KISS—POZSÁR 1972).

The stimulatory effect on protein synthesis of magnesium applied as a foliage spray was demonstrated using pea and millet as indicator plants (KISS—POZSÁR 1975).

The higher level of protein nitrogen is in itself no sufficient criterion of the increased field resistance; we therefore studied the change in the protein fractions in lettuce leaves sprayed

Table 4

Effect of systemic fungicides on the percentage distribution of protein fractions in Pinto bean leaves

Treatment	Molecular weights of protein fractions (1000 x)				
	12	24	36	120	400
Control	15.1	19.2	24.0	29.9	11.8
Benlate	19.3	24.2	25.0	29.0	2.5
Thiabendazol	20.6	24.7	25.8	26.6	2.3

Table 5

Changes in the soluble protein content of leaves as a response to magnesium nutrition

Treatment	Maize		Wheat		Bean	
	mg	percentage stimulation	mg	percentage stimulation	mg	percentage stimulation
Control	5.1	—	5.2	—	8.2	—
Magnesium treatment	5.9	15.8	5.5	5.7	8.5	3.6

The protein content refers to 250 mg fresh leaf. Highest deviation from the average: ±0.1 mg.

with magnesium sulphate 24 hours earlier (Table 6). The data in this table show that the increase in the level of the low molecular weight fraction (soluble in 0.5 per cent sodium chloride) is essentially greater than the change in the total protein concentration. This follows from the fact that after peptide synthesis it is the level of low molecular weight protein fractions which primarily rise. These data unequivocally prove the rejuvenating effect of magnesium as realized through the stimulation of protein synthesis, which can thus be regarded as a factor of field resistance.

If we interpret the effect of increased protein content to mean that the better nutrient supply results in more vigorous plant development, then the higher disease resistance — at least against those parasites which attack the weakened plant — seems to be brought into correlation with the protein metabolism. Increased field resistance as caused by magnesium nutrition is indirectly confirmed by data concerning the higher intensity of protein synthesis.

Thus, AKSENOVA *et al.* (1968) found that in cabbage plants infected by *Botrytis cinerea* the number of ribosomes increased parallel with the infection. This process is more intensive in varieties with higher pathological resistance than in susceptible ones, as was pointed out above for the protein synthesis. According to investigations made by ISRAEL—ROSS (1967) the protein synthesis is more intensive in the immediate neighbourhood of tissue lesions, developing as a result of hypersensitive reactions.

According to LIPSHITS (1972) potato varieties showing a pathological resistance to infection by *Phytophthora* may contain as much as 40 per cent more protein than the susceptible ones.

Table 6

Changes in the protein and magnesium contents of lettuce leaves as a response to $MgSO_4$ foliage spray, calculated for dry matter

Treatment	Total protein		Soluble protein		Magnesium content, mg %
	%	stimulation, %	%	stimulation, %	
Control	34.4	—	12.9	—	490
1% $MgSO_4$	36.6	6.5	14.3	11.6	530
Highest deviation from the average	±0.6	—	±0.4	—	±15

The stimulatory effect of magnesium on the protein synthesis is explained by its influence on the ribosomes and the role it plays in the ATP energy supply.

McCharty (1962) proved by measurements that the extent of protein synthesis was proportionate to the number of ribosomes. According to Wettstein *et al.* (1963) the protein synthesis takes place along a polyribosome chain, which Warner *et al.* (1962) confirmed by means of radioactive amino acid.

Magnesium plays an important role in maintaining the polyribosomic structure. By means of electron microscope examinations Palade (1956) pointed out that the ribosomes were linked like beads along the polyribosome, though only at the critical 10^{-3} mole Mg concentration. The magnesium, as a cation maintaining the structure, has the role of linking the ribosomic protein to the RNA, as directly proved by Goldberg (1966) at cell level.

Protein synthesis — like any synthesis — is a process requiring energy, which is supplied by the ATP. Of all the roles played by magnesium in processes related to ATP we will confine ourselves to quoting an amination reaction, the synthesis of glutamine:

$$\text{Glutamate}^{2-} + \text{ATP}^{4-} + \text{NH}_4^+ \rightarrow \text{Glutamine}^- + \text{ADP}^{3-} + \text{HPO}_4^{2-} + \text{H}^+$$

The reaction is catalyzed by the glutamine-synthetase enzyme which is activated by magnesium. Benzinger (1956) demonstrated the free energy changes in the reaction by microcalorimetric examinations. He found the free energy change at 37°C and pH 7 to be −7.0 kcal/mole in a medium containing magnesium, and −9.34 kcal/mole in the absence of magnesium. According to Khalil (1966), magnesium promotes the energy delivery by linking the ATP and the enzyme to be activated with a co-ordinative bond, in the form of a so-called outer spheric complex.

Thus it plays the role of a coenzyme bringing the two molecules close to each other and thereby facilitating the energy transport. A similar role is played by magnesium in the mitochondria.

*

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THE GERMINATION MECHANISM AND ITS ECOLOGICAL SIGNIFICANCE IN THE WEED *DIGERA ALTERNIFOLIA* ASCHERS

Digera alternifolia Aschers Syn. *D. arvensis* Linn. is one of the common weeds of the crop fields of the country. The seeds usually fail to germinate in the laboratory. Seeds kept under different temperatures for different durations and alterations, failed to germinate. To achieve germination different storage conditions (such as dry and moist storage at various temperatures in open and closed containers, also with lime, soil, calcium chloride, burial in soil at various depths, water logging, etc.), different pretreatments (such as with acids, alkalis, alcohol, glycerine, hydrogen peroxide, carbon tetrachloride for various durations, solutions of carbonates, nitrates, chlorides, urea, thiourea, gibberellic acid, etc.) and moistening agents (such as soil extract, 0.2% solution of nitrates, lime water, etc.) were employed. But in most of the conditions either the seed failed to germinate in the first three or four months or germinated to an extent of less than 10% (DUBEY 1967).

In fact a great number of treatments and pretreatments separately and in combinations were tried in order to get a maximum percentage of germination in a minimum length of time in the laboratory. The described conditions and pretreatments in their particular combinations were found suitable and can well be compared with conditions possibly existing in nature.

Certain mechanisms for germination have been described by BARTON (1936), MALL (1954), KOLLER (1955), KOLLER—NEGBI (1955) and REES (1962). The effect of several factors in germination was studied by STEINBAUER—GRIGSBY (1957), DAVIS—MCCARTY (1966) and DUBEY—MALL (1972). The role of promoting substances from crop root exudates was shown by SUNDERLAND (1960) and KUST (1966). But the combination of many factors required for germination by this seed appears to be important and hence the details of the study are given below. The study presents the role of certain factors in the germination of more and more seeds of the weed in a shorter and shorter period under laboratory conditions.

Seed collection. Nuts, hereafter called seeds (AMEN 1964), were collected at various time intervals from the crop fields of Ujjain and other parts of the country. The seeds were stored in glass bottles.

Germination. Seeds were placed for germination on double layers of moist filter paper in Petri dishes. A seed was considered to be germinated when the radicle emerged.

Experiment 1. Germination of seeds at room temperature and at 15°C: The seeds collected on 15th October, 1st November and 15th November 1965 were placed for germination, the day after collection.

Result. No seeds were able to germinate in the first 8 months, although they were viable.

Experiment 2. Germination of seeds at 35°C: The seeds collected on the dates described in Experiment 1 were kept for germination at 35 ± 1°C.

Result. In 10 months time the germination was less than 10%, irrespective of the date of collection. But this condition appears to be better than room temperature and 15°C. It was found that in the first 3 months no seeds were able to germinate (Table 1).

Experiment 3. Effect of duration and temperature during dry storage: Glass bottles containing seeds were kept for a varying number of months at 15°C, 35°C and 45°C (for the

Table 1

Germination of seeds at 35°C

Date of collection	Percentage of germination in the months										Total
	1	2	3	4	5	6	7	8	9	10	
15th October, 1965	—	—	—	1	—	—	2	—	2	4	9
1st November, 1965	—	—	—	1	1	—	2	—	1	1	6
15th November, 1965	—	—	—	1	1	1	—	4	1	—	8

whole 24 hours at each temperature), room temperature and at an alternation of 35°C to 15°C for 18/6 hours, respectively. Seeds from these bottles were kept for germination at 35°C ± 1.2°C.

Result. The most suitable condition for better germination appeared to be the 45°C temperature and storage at this temperature for about 6—8 months. Longer storage appeared to be injurious (Table 2).

Experiment 4. Effect of washing the Petri dishes containing seeds for germination: Noting the effect of duration and temperature, the seeds utilized in all further experiments were stored at 45°C ± 1.7°C for 7 months. Such pretreated seeds were kept for germination at 35 ± 1.2°C and the Petri dishes were washed daily, weekly and monthly with tap water.

Result. Washing had a significant effect, since daily washing resulted in 31% of the seeds germinating in a 4-month period. In the 5th month and onwards the germination was low and nil respectively (Table 3).

Experiment 5. Effect of scarification on pretreated seeds with daily washing: Seeds stored for 7 months at 45 ± 1.7°C were scarified with conc. sulphuric acid for various durations (in minutes). The Petri dishes containing the seeds were kept at 36 ± 1.2°C and were washed daily.

Result. Acid scarification for 45 minutes proved helpful in increasing the percentage of germination to 34 in three months. In later months the germination was very poor, even in the 4th month it only increased by 3%. Also, a scarification time shorter or longer than 45 minutes, respectively, had a reduced or injurious effect on the seeds (Table 4).

Table 2

Effect of storage durations and temperature during storage on germination

Storage temperature, °C	Per cent of seeds germinated					
	Storage durations in months					
	2	4	6	8	10	12
15 ± .6	—	—	1	5	8	8
35 ± 1 15 ± .6 (18 6hr. resp.)	—	1	1	7	12	13
35 ± 1	1	1	4	8	14	17
45 ± 1.7	3	10	20	24	17	12
Lab. temp. 28 ± 1.4 (control)	—	—	2	5	5	12

F for temperature, duration and interaction significant at 0.001 level.

Table 3

Effect of washing on germination

Washing interval	Percentage germination in months					Total, %
	1	2	3	4	5	
Daily	6	9	10	6	1	32
Weekly	4	4	7	5	2	22
Monthly	3	4	2	4	1	14
Control (no washing)	1	0	2	1	5	9

F for washing significant at 0.01 level.

Experiment 6. Effect of crop root exudate on germination: Seeds stored at 45 ± 1.7°C for 7 months, scarified for 45 minutes and thoroughly leached, were soaked in a solution of promoter for 4 hours. These seeds were kept for germination at 35 ± 1.2°C. The promoter was used to moisten the filter paper instead of water. Different grades of the promoter were made and used.

The promoter solution was prepared by putting 100 germinating seeds of *Sorghum vulgare* Pers into Petri dishes containing 10 ml water for 5 days. This volume was always made up to 10 ml during these 5 days by adding subsequently required water. The decanted liquid was named promoter solution.

Result. The promoting effects of root exudates are significant, as within 2 months the germination percentage increased to 60 (when the undiluted solution of promoter was used). The effect of the promoter was much reduced when it was diluted 100 times (Table 5).

Digera alternifolia Aschers is a well known weed of the crop fields of the country. A three and a half year study of germination revealed interesting mechnisms which are of "immense ecological significance in the life cycle of such successful weeds" (HARPER 1957).

The observation that the seeds fail to germinate in the first 3—4 months but start germination after this period clearly points towards after-ripening of the seed. Storage of the seeds at a higher temperature (45 ± 1.7°C) and the resultant increases in germination lead to the conclusion that temperature enhances the after-ripening processes and have in addition

Table 4

Effect of acid scarification on germination in addition to preceding treatments

Acid scarification, min.	Percentage in fortnights								Total, %
	1	2	3	4	5	6	7	8	
15	1	1	4	3	1	3	1	—	14
30	1	2	5	7	2	5	1	—	23
45	3	7	8	5	7	4	2	1	37
60	2	1	5	8	7	2	—	—	25
Control (no washing and no scarification)	—	—	1	1	4	1	—	—	7

F for scarification and time significant at 0.001 level.

Table 5

Effect of promoter on germination of pretreated seeds

Dilution of promoter	Per cent germination in two months
1 : 0	60
1 : 10	39
1 : 100	27
No promoter	22

a weathering effect on the seed (fruit) coat. A similar condition of temperature is available in nature from March to July when the temperature ranges between 35 and 44°C. The significant effect of leaching shows the presence of some inhibitor in the seed. The scarification just affects the increase in the imbibition of water by the coat, which in nature is possibly met by the weathering caused by higher temperatures and also by microbial activity. Further, the increased percentage of germination of such pretreated seeds in the presence of the crop root exudate will mean only that a promoter is also necessary to enhance the processes by which the embryo becomes a seedling.

Henceforth it becomes clear that the seed expresses an embryonal dormancy, a seed coat dormancy, an inhibitor in the body and needs promoting substances too. A successful germination of weed seed thus requires various conditions and is rather a case of multi-factorial germination. In fact the lack of any of these pretreatments can lengthen the period of germination and can make the latter intermittent. All these conditions or factors in nature are comparable with the conditions such as rest period, summer temperature, rainfall and the root exudates from the crop to which the seed is naturally exposed.

A combination of all such conditions safely exists in the crop fields, which thus become an ideal habitat for the establishment of the weeds. One interesting feature was noted: all these necessary treatments, which were given in the laboratory, either had little effect on the seed if they were applied to fresh seeds in the first 3—4 months, or the seed behaved indifferently to these conditions during this period and completely failed to germinate.

All these factors, ecologically speaking, can be covered by the word adaptation, because, when the fate of a weed is controlled by a definite need for restricted ecological conditions they are then bound to adjust and adapt (MALL 1954). Indeed if all the conditions are seen in correlation to the life cycle of the weed, they will prove to be adjustments instead of ecological hurdles (BILLINGS 1957). The validity of this statement can be understood by the following description.

The incapability of a fresh seed to germinate is nothing but an escape from the damage to itself, because by the time it is shed (October—November) from the plant, the moisture in the soil remains inadequate to leach out the inhibitor. Henceforth the weed seed undergoes a period of rest during which the after-ripening takes place. By this time, the summer (April—June) starts and the higher temperatures of the season are utilized for enchancing the after-ripening and weathering of the coat as well. At the end of June the rain breaks which will enable the leaching of the inhibitor and will supply enough moisture for the crop seed to germinate. So, while the seed is preparing for germination, the crop seedlings will come up, releasing the exudate from the roots and helping the weed seed to germinate and grow better.

This is a great physioecological achievement of this weed, as it utilizes the crop's material in order to grow and to damage the former in later days. This physiological setup of *Digera alternifolia* is a baffling problem for the farmers who leave the fields abandoned for a year

in the hope that all the seeds of the weed will come up and he will uproot the seedlings, but on the basis of the above account, this hope is groundless. It is thus worth stating that every stage of the weed's seed and its germination is a well adapted ecological stage, and the weed has moved to a high level of ecological attainment.

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EFFECT OF NUTRITION ON THE NUTRIENT COMPOSITION IN DIFFERENT PARTS OF TOMATOES

The determination of the nutrient elements found in the different plant parts makes it possible to estimate the nutrient conditions in tomato plants. For greenhouse tomato production a number of authors have established limit values, and the results of leaf analyses can thus be used directly in nutritional practice (WARD 1963, SMILDE—ROORDA VAN EYSINGA 1968).

Data on the composition of the fruit were published in a summarizing work written by SOMOS (1971), while information on the nutrient content of the seed was given by SOMOS *et al.* (1962) and TÖLGYESI (1969). Many details have been cleared up in hydroponic and pot experiments concerning the interaction of the nutrient elements as well as their effect on the fruit and its quality (HOWLETT—KRETCHMAN 1968, SHARMA *et al.* 1968, HIPP—GERARD 1969, FONG 1973).

In the plant parts the quantity and ratio of the different macro- and microelements change during the vegetative period (FERENCZ *et al.* 1964). The concentration of the nutrient elements is also influenced by the environmental conditions (CANNELL *et al.* 1963, ORTH 1973). This all makes it difficult to interpret the results of plant analyses in field production, although the large number of examinations make it possible to discover certain correlations. For example, BRADLEY—FLEMING (1960) found a close positive correlation between the phosphorus content of leaf samples taken in the first third of the vegetative period and the amount of fruit yield. HOWLETT (1970) presented limit values for the most important elements.

Our present work is aimed at studying the effect of extreme treatments on the nutrient composition of leaf, fruit and seed in a nutrition trial carried out at the Vegetable Crops Research Institute on tomatoes intended for processing. It was also aimed at finding correlations between the elements and the quantity and quality of fruit yield and also between the individual elements.

For the examinations samples of plant parts were taken from extreme treatments of a second year long-term nutrition trial set up on a meadow chernozem soil of loamy sand at the Borbás station of the Vegetable Crops Research Institute.

The nutrition treatments were as follows:

No. of treatment	N	P_2O_5	K_2O
	kg/ha		
1	0	0	0
2	150	150	150
3	0	100	100
4	150	100	100
5	100	0	100
6	100	150	100
7	100	100	0
8	100	100	150

Half the nitrogen fertilizer was worked into the soil before planting, the other half after the setting of the first cluster; in the case of phosphorus and potassium fertilizers 75% was worked in in autumn and 25% in spring. The average analytical results for soil samples taken before the fertilizer application were: pH (H_2O): 7.7; pH (KCl): 7.4; capillary water rise in 5 hours: 328 mm; h_y: 1.8%; K_A: 29; total salt: 0.03%; $CaCO_3$: 1.9%; humus: 1.87%; AL P_2O_5: 16.8 mg/100 g; AL K_2O: 11.8 mg/100 g.

The trial was arranged in a random block design with 6 replications using the variety Kecskeméti Jubileum, transplanted on 6th May 1974.

Leaf samples were taken on three occasions: 20th June when the first cluster set, 9th August prior to the beginning of picking, and 12th September when the foliage started to decline rapidly. On the first two occasions lower and upper leaves, and in the last case only upper leaves were collected.

To examine the quality and nutrient composition of the fruit and the nutrient content of the seed 30 fruit samples per treatment and replication were taken on 27th August, the time of mass picking.

The leaf and seed samples were dried at 80°C, then ground. The analysis of the individual elements was performed with air-dry material. The nitrogen content was determined using the method described by SARKADI—KRÁMER (1961) after destruction with sulphuric acid. All the other elements were analysed from samples reduced to ashes. From a stock solution prepared according to a method recommended in the GDR (BERGMANN 1964) the phosphorus, magnesium, boron and iron were determined by colorimetry, and the calcium, sodium and potassium by flame photometry. Manganese, zinc and copper were demonstrated with a polarograph according to a method described in an earlier publication (PROHÁSZKA—GURABI 1974).

The stock solution required for the analysis of tomato fruits was prepared using the wet destruction method published by TÖLGYESI (1969). From the stock solution the elements were determined in the manner described above. The statistical evaluation was carried out according to SVÁB (1973).

The yield results of the nutrition treatments and the dry matter content of the fruit are presented in Table 1. The results of leaf, fruit and seed analyses are summed up in Tables 2—4.

Nutrient composition in leaves collected at different times. The nutrient distribution in the tomato leaves collected at the first sampling was characterized by the mobile elements accumulating in the upper, and the immobile ones in the lower leaves (Table 2).

The largest quantity of nitrogen was found in the leaves of plants given a high-rate complete fertilization (Treatment 2). The lowest amount of nitrogen was found in Treatment 3, where the level of the element in question was even lower than in the control (Treatment 1). The nitrogen content of plants given a rich phosphorus nutrition (Treatment 6) was also lower than that of those in the phosphorus-deficient treatment (5). Thus, in our experiment phosphorus nutrition decreased the nitrogen content of the tomato leaves.

The distribution of phosphorus in the treatments was in inverse ratio to that of the nitrogen. The highest amount of phosphorus was found in the leaves with the lowest nitrogen

Table 1

Effect of nutrition treatments on the yield and dry matter content of tomato

No. of treatment	Fertilizer doses, kg/ha			Early yield, q/ha	Total yield, q/ha	Dry matter content in fruits from mass picking
	N	P_2O_5	K_2O			
1	0	0	0	175.9	290.9	6.62
2	150	150	150	265.0	469.9	7.69
3	0	100	100	239.6	443.3	6.69
4	150	100	100	237.2	435.2	7.54
5	100	0	100	153.9	251.1	6.71
6	100	150	100	261.6	500.0	7.29
7	100	100	0	243.0	488.4	7.59
8	100	100	150	238.4	459.5	7.60
S.D. 5%				34.7	40.5	0.21

Table 2

Changes in the major macro- and microelements

No. of treatment	Fertilizer doses, kg/ha			N, g/kg		P, g/kg		K, g/kg		Na, g/kg	
	N	P_2O_5	K_2O	l	u	l	u	l	u	l	u
											First sampling:
1	0	0	0	28.2	36.9	2.05	2.45	24.6	24.6	3.66	2.36
2	150	150	150	33.0	39.1	2.35	3.20	22.2	28.2	3.85	2.48
3	0	100	100	27.2	34.6	2.85	3.90	26.2	29.1	3.40	2.00
4	150	100	100	30.3	36.9	1.55	2.65	21.4	25.9	2.76	2.36
5	100	0	100	29.9	38.1	1.45	1.95	27.5	29.5	3.59	2.48
6	100	150	100	27.3	36.8	2.20	3.20	26.8	29.0	3.28	1.98
7	100	100	0	28.4	35.9	2.05	3.00	22.0	26.6	3.28	2.48
8	100	100	150	28.4	37.3	2.20	2.70	27.2	26.1	3.78	2.18
											Second sampling:
1	0	0	0	18.3	25.8	1.25	1.80	9.0	6.9	5.55	7.80
2	150	150	150	19.6	29.1	0.90	1.25	7.4	10.2	6.40	4.70
3	0	100	100	19.7	29.1	1.35	1.55	12.2	11.2	5.85	5.85
4	150	100	100	21.7	30.7	1.10	1.50	8.7	9.9	5.55	6.80
5	100	0	100	20.1	23.4	1.10	1.55	7.9	7.4	6.40	7.25
6	100	150	100	22.1	25.5	1.20	1.75	11.4	15.6	5.55	5.00
7	100	100	0	20.7	28.8	1.45	1.90	11.2	10.3	4.45	3.10
8	100	100	150	20.1	29.1	1.30	1.80	12.7	13.7	5.00	4.70
											Third sampling:
1	0	0	0	—	26.2	—	1.46	—	7.0	—	7.78
2	150	150	150	—	21.0	—	1.49	—	5.8	—	6.76
3	0	100	100	—	22.5	—	1.67	—	5.9	—	6.76
4	150	100	100	—	22.6	—	1.65	—	5.6	—	7.36
5	100	0	100	—	26.0	—	1.67	—	5.9	—	7.54
6	100	150	100	—	22.8	—	1.52	—	8.1	—	6.20
7	100	100	0	—	24.7	—	1.55	—	7.8	—	6.76
8	100	100	150	—	27.5	—	1.44	—	6.0	—	6.10

level. Plants given a high-rate complete fertilization or abundantly supplied with phosphorus (Treatments 2 and 6) also had a high phosphorus content.

The nitrogen-deficient nutrition increased not only the phosphorus supply to the leaves but also the potassium content. A relatively high potassium level was also found in the phosphorus-deficient treatment (5).

of tomato leaves during the vegetative period

Ca, g/kg		Mg, g/kg		Fe, mg/kg		Mn, mg/kg		Zn, mg/kg	
l	u	l	u	l	u	l	u	l	u
20th June 1974									
56.0	32.3	2.48	2.55	421.5	348.5	137.0	85.0	61.6	53.3
59.1	34.8	3.06	2.30	546.5	351.0	145.0	75.0	59.7	52.4
55.6	28.5	2.60	2.02	433.5	416.2	120.0	90.0	65.5	50.2
50.5	30.8	2.80	2.80	216.5	330.5	80.0	50.0	48.4	51.5
50.3	31.9	2.95	2.80	462.5	434.0	152.0	100.0	41.6	57.0
46.5	25.9	2.90	2.10	516.5	316.0	95.0	67.0	46.3	31.9
42.6	30.1	2.60	3.10	481.0	379.5	127.0	68.0	52.2	46.8
49.0	25.4	2.60	2.70	417.0	361.0	110.0	50.0	42.9	42.1
9th August 1974									
50.0	46.4	2.80	2.72	380	315	256.2	310.0	21.8	23.6
57.5	43.4	3.04	2.72	397	307	262.5	355.5	30.3	35.3
41.0	40.0	3.12	2.57	360	285	258.7	310.0	28.8	29.0
57.0	47.2	2.88	2.88	410	365	305.0	306.2	27.9	32.7
61.5	50.5	3.00	2.78	515	307	287.5	340.0	30.2	30.1
61.5	44.7	2.37	2.42	270	310	302.5	315.0	26.1	27.0
45.9	31.5	2.44	2.54	410	537	230.0	220.0	19.6	20.9
57.5	40.0	2.72	2.60	317	317	310.0	362.5	23.9	30.1
12th September 1974									
—	80.0	—	8.99	—	705.0	—	527.5	—	28.1
—	79.9	—	9.00	—	801.2	—	522.5	—	29.7
—	75.0	—	8.90	—	608.7	—	505.0	—	33.6
—	74.0	—	9.15	—	707.0	—	487.5	—	30.2
—	78.4	—	9.17	—	732.5	—	480.0	—	29.5
—	75.0	—	9.40	—	806.0	—	422.5	—	28.5
—	71.6	—	9.40	—	523.0	—	455.0	—	29.0
—	72.6	—	9.70	—	407.0	—	455.0	—	25.2

The different rates of nutrition treatment caused hardly any change in the sodium and magnesium levels in the leaves, while the high-rate complete fertilization (Treatment 2) increased the calcium, iron and manganese contents. In the nitrogen- and phosphorus-deficient treatments (3 and 5) the manganese content of the leaves was even higher than in plants given a complete fertilization (Treatment 2). The level of zinc in the leaves was relatively

constant, except for the treatment rich in phosphorus, where a decrease in the zinc content was observed. A similar conclusion was reached by OLSON *et al.* (1965) with maize and sorghum.

Nutrition was found to cause the above changes in the nutrient content of the tomato leaves. It is questionable, however, whether this effect of the different rates and proportions of fertilizers on the nutrient content has anything to do with the yield, or rather which of the examined elements is either directly or indirectly connected with the fruit yield of the tomato plant. The correlation study showed a close correlation between the phosphorus content of upper leaves collected when the first cluster was setting and the early and total fruit yield ($P = 5\%$, $r = 0.75$, $n = 8$, and $P = 5\%$, $r = 0.72$, $n = 8$, respectively).

The distribution of nutrients as a response to nutrition treatments was roughly the same in leaves collected in August. The treatment effects observed earlier had become somewhat confused, however. Some elements, such as sodium, calcium, magnesium, iron and manganese increased, while others (nitrogen, phosphorus, potassium, zinc) decreased in quantity.

As a consequence of differences in nutrition a very close negative correlation was found between the phosphorus and zinc contents of the leaves in this period of observation ($P = 1\%$, $r = -0.88$, $n = 8$). A negative correlation was also found between potassium and magnesium ($P = 5\%$, $r = -0.72$, $n = 8$).

In leaf samples collected in September only the nitrogen and iron contents showed a slight difference. In this period the nitrogen, phosphorus, potassium and zinc levels were sharply reduced, while the other elements increased in quantity.

Nutrient content in tomato fruits. The changes due to fertilizer application in the nutrient contents of tomato fruits picked in the main harvesting period are contained in Table 3. The results of the analyses show that the different rates of nutrition only affected a few elements and even in these caused only a slight quantitative change.

An abundant potassium supply significantly increased the nitrogen and manganese contents of tomato fruits, and decreased their calcium and sodium contents. In spite of the fact that no significant change occurred in the potassium content, there was a close positive correlation between the nitrogen and potassium contents of the fruits ($P = 5\%$, $r = 0.75$, $n = 8$). The correlation between potassium and magnesium was similarly close, but negative ($P = 5\%$, $r = -0.74$, $n = 8$).

The varying rate of fertilizer application resulted in significant differences in the water soluble dry matter content of the tomato. The highest values were obtained with the high-rate complete nutrition (Treatment 2), followed by the treatments rich in nitrogen, phosphorus and potassium, (4, 6, 8), which were significantly higher than that in the control (Treatment 1) and in the nitrogen- and phosphorus-deficient treatments (3 and 5).

Nutrient content in tomato seeds. The smallest change caused by the fertilizers applied in the experiment was observed in the nutrient content of tomato seeds (Table 4). Table 5 presents the variation coefficients for the ash components in the upper leaves from the first sampling, and in the fruits and seeds. It can clearly be seen that the changes caused by the fertilizers in the components of the different plant organs decrease in the following order: leaf—fruit—seed.

This can partly be explained by a high degree of constancy in the seeds within a plant species (TÖLGYESI 1969). Nevertheless, external conditions, such as the nutrient level and other qualities of the soil for example, may modify this relative constancy within certain limits characteristic of the species. The doses applied in our trial seem to have been too low to induce the above-mentioned changes. Nevertheless, our results point to the zinc-reducing effect of a higher rate of phosphorus nutrition (Treatment 6). At the same time, a higher rate of mixed fertilizer application was found to increase the copper content of the seeds compared to the control (Treatment 2).

Table 3

Effect of nutrition on the nutrient composition of tomato fruits

No. of treatment	Fertilizer, kg/ha			N	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu	B
	N	P_2O_5	K_2O	g/kg						mg/kg				
1	0	0	0	1.97	0.14	2.03	0.30	0.74	0.29	4.7	0.80	1.21	0.96	0.33
2	150	150	150	1.97	0.11	2.01	0.30	0.93	0.25	4.3	0.83	1.02	0.94	0.27
3	0	100	100	1.82	0.11	2.11	0.31	0.83	0.21	3.9	0.89	1.13	1.20	0.28
4	150	100	100	1.96	0.13	2.08	0.31	0.83	0.25	4.8	0.87	1.16	1.13	0.29
5	100	0	100	1.95	0.15	2.13	0.31	0.68	0.25	4.1	0.80	0.94	0.86	0.29
6	100	150	100	1.84	0.10	1.87	0.30	0.94	0.23	3.8	0.86	1.14	1.05	0.30
7	100	100	0	1.89	0.09	2.03	0.29	0.78	0.23	4.6	0.88	0.75	1.02	0.29
8	100	100	150	2.16	0.12	2.33	0.28	0.72	0.21	4.3	0.89	1.11	0.98	0.28
S.D. 5%	—	—	—	0.17	NS	NS	0.02	NS	0.05	NS	0.05	NS	NS	NS

Table 4

Effect of nutrition on the major macro- and micro-element content of tomato seeds

No. of treatment	Fertilizer, kg/ha			N	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu
	N	P_2O_5	K_2O	g/kg						mg/kg			
1	0	0	0	44.8	7.91	4.32	0.60	3.28	0.20	138.2	23.8	17.8	13.9
2	150	150	150	44.3	8.13	4.18	0.62	3.42	0.21	140.0	21.2	16.8	16.1
3	0	100	100	44.8	7.60	4.29	0.60	2.75	0.21	131.6	19.2	15.2	13.0
4	150	100	100	44.1	7.68	4.05	0.55	2.10	0.22	130.2	23.1	16.1	15.6
5	100	0	100	44.4	7.38	3.92	0.54	2.11	0.19	136.5	22.0	15.4	11.7
6	100	150	100	44.0	7.50	3.79	0.60	3.10	0.19	136.6	34.7	13.1	13.6
7	100	100	0	43.4	7.94	3.93	0.56	3.10	0.20	140.3	26.5	18.4	13.0
8	100	100	150	44.9	7.41	4.92	0.70	3.17	0.26	157.5	27.5	17.9	15.3
S.D. 5%				NS	NS	NS	NS	NS	NS	NS	NS	—	2.32
S.D. 10%												3.0	

Table 5

Changes in the variation coefficients of some ash components in the order leaf — fruit — seed

Ash component	Leaf	Fruit	Seed
P	21	16	10
K	10	9	8
Ca	11	9	8
Fe	22	8	6
Mn	24	16	11
Zn	16	15	11

Our results also show that in the nitrogen-deficient treatments the copper content of the tomato seeds was low, while nitrogen nutrition significantly increased the copper content in the plant organs examined. This suggests a relationship between copper and nitrogen.

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THE EFFECT OF DIFFERENT COMBINATIONS OF SOIL SALINITY AND NITROGEN LEVELS ON MINERAL COMPOSITION OF COTTON PLANTS

Certain trials, though few, have been devoted to the study of the combined effect of soil salinity and nitrogen levels on the growth and yield of cotton plants (KORTAM 1973). In order to interpret the results obtained, it seems of special importance to investigate the changes shown by the mineral composition of plants under such conditions, particularly with regard to the contents of the three elements: N, P and K; and accordingly the present work was designed.

It should be recognized that, even at normal rates of nitrogen fertilization, there is at present a considerable lack of information concerning the manner of response exhibited by the mineral composition of cotton plants to salinity. Amongst the few publications available in this respect is that of STROGONOV (1962). In this investigation, it appeared that, under salinization conditions, the relative content of potassium as well as the total amount of either potassium or phosphorus in cotton plants were lowered.

The present work was conducted during the 1970 season, in the greenhouse at the Botany Laboratory, National Research Centre, Dokki, Cairo, using cotton plants *(Gossypium barbadense)*, cultivar Giza 66. Metal containers (from tins), measuring 30 cm in diameter × 50 cm in height, were used. The inner surface of the pots was coated with three layers of bitumen to prevent direct contact between the soil and metal. Every pot contained 30 kg of air-dried Nile clay soil; and a special drainage system was employed, so that water movement was from the base upwards. Seed-sowing was on March 3, few seeds being sown in each pot. The seedlings were thinned after the appearance of the first foliage leaf to leave four seedlings/pot. Rethinning was carried out at the appearance of the second foliage leaf to leave only two seedlings/pot.

Three salinity levels were employed: 0, 0.4 and 0.8% (from the dry weight of the soil) the salt used for investigation being a mixture of sodium sulphate and sodium chloride at a, ratio of 10 : 1 for the SO_4^-/CO^- ions. Within each of the employed salinity levels, four concentrations of nitrogen in the form of ammonium nitrate were supplied, namely, 0, 2.5, 5 and 10 g N/pot. Thus, such a scheme included 12 treatments, each with 15 replicates. The salt mixture

as well as the nitrogen fertilizer were added in portions to the soil with the irrigation water, starting from the appearance of the third foliage leaf. At this particular time, only one half of the salt dose together with two-fifths of the amount of nitrogen fertilizer were supplied; then one week later, each pot received the second half of the salt mixture dose together with another portion of the nitrogen fertilizer equal in amount to that added at the first time. The remaining portion of ammonium nitrate salt, however, was supplied just before the onset of the square stage. Phosphorus and potassium fertilizers were added to the soil before sowing, at a rate of 5 g P_2O_5/pot in the form of calcium superphosphate for the former and 2 g K_2O/pot in the form of potassium sulphate for the latter. The plants were maintained throughout development at 65% of the soil water-holding capacity.

Five samples (at 15-day intervals) were collected: the 1st at early square (on 4th May, i.e. 61 days after sowing), the 2nd at late square, the 3rd at early bloom, the 4th at peak bloom, and the last at the boll formation stage. For each sample, six plants from three separate pots were taken. These plants were separated into different parts. Both leaves and stems (including lateral branches) were dried at 70°C for 48 hours, then finely ground and for each different part the dried materials from the six plants of each sample were mixed together and kept for the following chemical analyses:

1) Total nitrogen, determined colorimetrically as described by YUEN—POLLARD (1952).

2) Total phosphorus (P_2O_5), determined colorimetrically as described by SNELL—SNELL (1954).

3) Potassium (K_2O), determined by flame photometer as described by BROWN—LILLELAND (1946).

Relative content of total nitrogen. From Table 1, it appears that the influence exerted upon the N content in plant tissues due to a given rise in the salinity level (compared with the control, i.e. 0% salinization) was a function of the soil N concentration, the part of the plant, and the developmental stage. Thus, when considering the mean values (irrespective of soil N level), it was shown that each of the salinization degrees: 0.4% and 0.8% always led to a lowering effect in this regard in the case of the stems, compared with the control. Even in the case of the leaf tissues, this type of effect was noticed at the boll formation stage when applying either salinity level, as well as at most other sampling dates for the 0.8% salt concentration only. Nevertheless, the reverse proved to be true with respect to the 0.4% salinity degree during the period prior to boll formation.

According to the data presented in Table 1, it appears further that, at each of the salinity levels used, the N content in either leaves or stems was shown in the great majority of cases throughout plant development to be increased due to the application of any of the soil nitrogen doses, compared with plants grown on N-free substrate.

Relative content of total phosphorus. From Table 2, it appeared that at each of the soil N concentrations used, the 0.8% salinity degree was shown in most cases to cause a lowering effect on the P content in leaves and stems, compared with the control (i.e. 0% salinization level); but there was no consistent trend with respect to the effect of 0.4% salinity degree in this regard.

The data presented in Table 2 indicate further that, at all salinity levels used, the P content in either leaves or stems generally appeared to be decreased due to the application of any of the nitrogen doses, compared with plants grown on N-free substrate.

Relative content of potassium. From Table 3, it appears that the influence exerted upon the K content in plant tissues due to a given rise in the salinity level (compared with the control) was a function of the magnitude of the N dose, the part of the plant and the developmental stage. However, when considering the mean values (irrespective of soil N concentration), it was shown that each of the salinization degrees led in most cases to a lowering effect in this regard (compared with the control) for both leaves and stems.

Table 1

Relative content of nitrogen in cotton leaves and stems (mg/g dry weight) at different developmental stages as influenced by salinity and nitrogen levels in soil

Salt concentration (%)	Nitrogen dose (g N/pot)	Developmental stages									
		Early square		Late square		Early bloom		Peak bloom		Boll formation	
		Leaves	Stems	Leaves	Stems	Leaves	Stems	Leaves	Stems	Leaves	Stems
0.0	0.0	5.23	4.51	4.52	3.51	5.51	4.28	4.08	3.52	4.52	3.06
	2.5	7.16	4.72	5.63	4.52	8.03	4.65	8.53	3.76	6.32	3.25
	5.0	7.24	5.01	6.13	5.21	8.21	4.25	8.73	4.21	7.65	3.42
	10.0	7.53	4.73	6.28	4.75	8.36	4.02	8.64	4.03	7.03	3.71
	Mean	6.79	4.74	5.64	4.50	7.53	4.29	7.50	3.88	6.38	3.36
0.4	0.0	5.74	3.52	5.26	4.26	5.76	4.03	4.56	3.67	5.21	2.79
	2.5	7.26	4.03	6.27	4.05	8.53	3.56	9.02	3.88	7.56	3.26
	5.0	7.52	4.56	7.13	4.26	8.79	4.37	9.23	3.76	6.05	3.21
	10.0	7.76	4.27	6.79	4.32	8.58	4.62	9.18	4.02	6.32	3.01
	Mean	7.07	4.10	6.36	4.22	7.92	4.15	8.00	3.83	6.29	3.07
0.8	0.0	5.03	3.26	4.37	4.02	5.09	4.02	3.79	3.26	4.36	3.06
	2.5	6.27	3.52	5.76	3.77	7.52	4.03	8.06	3.56	6.32	4.15
	5.0	7.03	3.46	6.28	4.52	7.78	4.28	8.15	3.42	5.72	3.01
	10.0	7.15	3.74	6.78	4.75	8.03	4.31	8.53	3.71	7.03	2.97
	Mean	6.37	3.50	5.80	4.27	7.11	4.16	7.13	3.49	5.86	3.30
Mean values for the effect of nitrogen level	0.0	5.33	3.76	4.72	3.93	5.45	4.10	4.14	3.48	4.70	2.97
	2.5	6.90	4.09	5.89	4.11	8.03	4.07	8.54	3.73	6.73	3.55
	5.0	7.26	4.32	6.51	4.66	8.26	4.30	8.70	3.80	6.47	3.21
	10.0	7.48	4.25	6.62	4.61	8.32	4.32	8.78	3.92	6.79	3.23

The data presented in Table 3 show further that, at all salinity levels employed, the values of the K content in either part of the plant were generally of higher magnitude under the conditions of N-application, than for plants grown on an N-free medium. When considering the mean values (irrespective of salinity level), a progressive increase in this regard was noticed in most cases as the soil N level was considerably raised.

Our results indicate that the relative content of nitrogen, phosphorus or potassium in cotton plants decreased in most cases under salinity conditions. These observations agreed with the findings, among others, of GAUCH—WADLEIGH (1945) with regard to N; PÁLFI (1965) with regard to P; STROGONOV (1962) for K. Such effects might partly be attributed to a much more pronounced decrease in the uptake of the above-mentioned three minerals than in dry matter accumulation under salinity conditions. The latter type of response was noticed by STROGONOV (1962) and KORTAM (1973) in cotton plants. The retarded uptake of minerals when using a saline substrate was reported, e.g., by GAUCH—WADLEIGH (1942) with respect to N; SHIMOSE (1963) with respect to K; STROGONOV (1962) in the case of P; though a consid-

Table 2

Relative content of phosphorus in cotton leaves and stems (mg/g dry weight) at different developmental stages as influenced by salinity and nitrogen levels in soil

Salt concentration (%)	Nitrogen dose (g N/pot)	Developmental stages									
		Early square		Late square		Early bloom		Peak bloom		Boll formation	
		Leaves	Stems	Leaves	Stems	Leaves	Stems	Leaves	Stems	Leaves	Stems
0.0	0.0	0.45	0.32	0.62	0.35	0.75	0.38	0.60	0.45	0.46	0.46
	2.5	0.42	0.28	0.62	0.32	0.68	0.37	0.58	0.43	0.45	0.45
	5.0	0.38	0.23	0.56	0.35	0.51	0.35	0.52	0.42	0.51	0.39
	10.0	0.39	0.23	0.52	0.28	0.53	0.36	0.45	0.38	0.41	0.42
	Mean	0.41	0.27	0.58	0.33	0.62	0.37	0.54	0.42	0.46	0.43
0.4	0.0	0.43	0.28	0.64	0.31	0.82	0.36	0.61	0.51	0.52	0.51
	2.5	0.41	0.26	0.58	0.28	0.81	0.35	0.54	0.43	0.45	0.48
	5.0	0.36	0.28	0.56	0.26	0.83	0.32	0.51	0.41	0.42	0.50
	10.0	0.34	0.25	0.52	0.24	0.71	0.30	0.48	0.35	0.35	0.42
	Mean	0.39	0.27	0.58	0.27	0.79	0.33	0.54	0.43	0.44	0.48
0.8	0.0	0.41	0.27	0.61	0.28	0.66	0.35	0.54	0.43	0.50	0.50
	2.5	0.37	0.25	0.55	0.31	0.58	0.25	0.50	0.38	0.44	0.46
	5.0	0.35	0.26	0.48	0.26	0.62	0.27	0.48	0.41	0.43	0.37
	10.0	0.32	0.21	0.51	0.24	0.58	0.24	0.51	0.37	0.41	0.41
	Mean	0.36	0.25	0.54	0.27	0.61	0.28	0.51	0.40	0.45	0.44
Mean values for the effect of nitrogen level	0.0	0.43	0.29	0.62	0.31	0.74	0.36	0.58	0.46	0.49	0.49
	2.5	0.40	0.26	0.58	0.30	0.69	0.32	0.54	0.41	0.45	0.46
	5.0	0.36	0.26	0.53	0.29	0.65	0.31	0.50	0.41	0.45	0.42
	10.0	0.35	0.23	0.52	0.25	0.61	0.30	0.48	0.37	0.39	0.42

erable amount of controversy exists in literature on the accumulation of the latter mineral under salinization conditions (GAUSMAN *et al.* 1958), that might point to the absence of a sharp-cut trend for the response exhibited by the relative content of P to salinity. In this regard, it might be pointed out that our results obtained for changes in the P content in plant tissues in the case of the 0.4% salinity level showed no consistent trend.

On the other hand, it was generally shown in our results that the content of either N or K in plant tissues was increased but that of P decreased due to N fertilization. The negative response of the P content to heavy N application in cotton plants was noticed by SAAD (1971). On the other hand, the positive influence exerted upon the relative content of N in such plants due to the same type of treatments was reported, among others, by VIVEKANANDAN *et al.* (1970). It seems that at high soil N levels, the stimulation in N uptake exceeds that exhibited by dry matter accumulation; the latter type of effect was shown, e.g., by KORTAM (1973) in cotton plants. The increase in N absorption by such plants following N fertilization was reported, e.g., by DASTUR (1962). In the same investigation, it was further indicated that this

Table 3

Relative content of potassium in cotton leaves and stems (mg/g dry weight) at different developmental stages as influenced by salinity and nitrogen levels in soil

Salt concentration (%)	Nitrogen dose (g. N/pot)	Developmental stages									
		Early square		Late square		Early bloom		Peak bloom		Boll formation	
		Leaves	Stems	Leaves	Stems	Leaves	Stems	Leaves	Stems	Leaves	Stems
0.0	0.0	1.52	1.25	1.63	1.13	1.26	1.01	1.87	1.32	1.64	0.88
	2.5	1.63	1.31	1.67	0.95	1.27	0.83	1.72	1.45	1.71	0.97
	5.0	1.65	1.32	1.82	1.42	1.64	1.32	1.98	1.41	1.82	1.03
	10.0	1.72	1.35	1.86	1.52	1.93	1.45	2.01	1.51	1.96	1.45
	Mean	1.63	1.31	1.75	1.26	1.53	1.15	1.90	1.42	1.78	1.08
0.4	0.0	1.52	1.05	1.67	1.16	1.18	1.04	1.29	0.97	1.39	0.95
	2.5	1.54	1.25	1.50	1.28	1.43	1.31	1.72	1.08	1.76	0.97
	5.0	1.62	1.42	1.75	1.07	1.55	1.42	1.92	1.19	2.21	1.05
	10.0	1.83	1.35	1.76	1.28	1.88	1.38	1.99	1.32	1.68	1.23
	Mean	1.63	1.27	1.67	1.20	1.51	1.29	1.73	1.14	1.76	1.05
0.8	0.0	1.13	1.03	1.19	0.85	1.23	1.18	1.16	0.95	1.65	0.91
	2.5	1.35	1.21	1.45	1.23	1.42	1.23	1.81	1.21	1.67	0.96
	5.0	1.52	1.18	1.52	1.62	1.53	1.36	2.07	1.42	1.65	1.28
	10.0	1.46	1.35	1.63	1.65	1.61	1.27	2.05	1.36	1.95	1.12
	Mean	1.37	1.19	1.45	1.34	1.45	1.26	1.77	1.24	1.73	1.07
Mean values for the effect of nitrogen level	0.0	1.39	1.11	1.50	1.05	1.22	1.08	1.44	1.08	1.56	0.91
	2.5	1.51	1.26	1.54	1.15	1.37	1.12	1.75	1.25	1.71	0.97
	5.0	1.60	1.31	1.70	1.37	1.57	1.37	1.99	1.34	1.89	1.12
	10.0	1.67	1.35	1.75	1.48	1.81	1.37	2.02	1.40	1.86	1.27

rise in N uptake was accompanied by a corresponding increase in K absorption. This type of finding, in turn, might point to the elevated values shown in our experiments for the K content at high soil N levels.

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TRITICUM TIMOPHEEVI ZHUK. WITH SHORT, CLOSE-PACKED SPIKES

The wheat species *Triticum timopheevi* Zhuk. was discovered by ZHUKOVSKY (1928) in West Georgia, in the foothills of the Caucasus (400—800 m above sea level). A characteristic feature of the species is the hairiness of the leaf. The spike is compact, awned, with a fragile spindle, difficult to thresh; the grain is longish.

Zhukovsky distinguished two varieties within the species, to which FLAKSBERGER (1935) gave the following taxonomic descriptions:

The spikes are yellow, pinkish or reddish, hairy, with red grains.

1. The awns are the same colour as the spike
   var. *typicum* Zhuk.
2. The awns are black
   var. *viticulosum* Zhuk.

Besides these two varieties ERITZYAN (1939) and MENABDE (1948) described five constant forms segregated from species hybrids of *T. timopheevi* Zhuk. Taking into consideration these new varieties MENABDE (1948) placed the varieties of *T. timopheevi* Zhuk. into two varietal groups (grex) on the basis of the length and compactness of the spike:

1. grex *compacto-planiusculum* Men.
   The spike is compact or very compact (D = up to 50).
   var. *rubiginosum* Eritz.
   var. *typicum* Zhuk.
   var. *viticulosum* Zhuk.
   var. *nigrum* Eritz.
2. grex *plano-supercompactum* Men.
   The spike is very compact (D = up to 50—70) and short (up to 4 cm).
   var. *pseudo-rubro-compressum* Men.
   var. *rubro-compressum* Eritz.
   var. *nigro*-compressum Eritz.

LELLEY—RAJHÁTHY (1955) and LELLEY—MÁNDY (1963) emphasize the poor morphological variability of *T. timopheevi* Zhuk. and describe no varieties. In his summarizing work ZHUKOVSKY (1964) only gives an account of the var. *typicum* Zhuk. (In the first half of the 20th century this type was grown in Georgia under the name Zanduri in combination with the species *T. monococcum* L. var. *hornemannii* Clem. and *T. zhukovskyi* Men. et Eritz. on an area of 400—500 ha.) According to SHIHARULIDZE (1968) the species *T. timopheevi* Zhuk. has two varieties. DOROFEEV (1972) also considers that no substantial morphological differentiation has taken place within the species. DOROFEEV (1972) presents Menabde's taxonomy for *T. timopheevi* Zhuk. but notes that with the exception of the two basic varieties the varieties described are constant forms selected from interspecific hybrids.

In 1950 Zhukovsky noticed a new type natural mutant in a *T. timopheevi* Zhuk. plot. The derivatives of the plant proved to be constant, therefore ZHUKOVSKY—MIGUSHOVA (1969) described it as a new species under the name *Triticum militinae* Zhuk. et Migush. This variety has the same ploidy level as *T. timopheevi* Zhuk. ($2n = 28$), and except for the properties of the spike its characteristic features are identical with those of the latter. The spike of *T. militinae* Zhuk. et Migush. is very compact (D = 50—70), very short (3.5—4.5 cm) and black when ripe.

Fig. 1. Triticum timopheevi Zhuk. var. *compactum* Szalay and var. *timopheevi* spikes

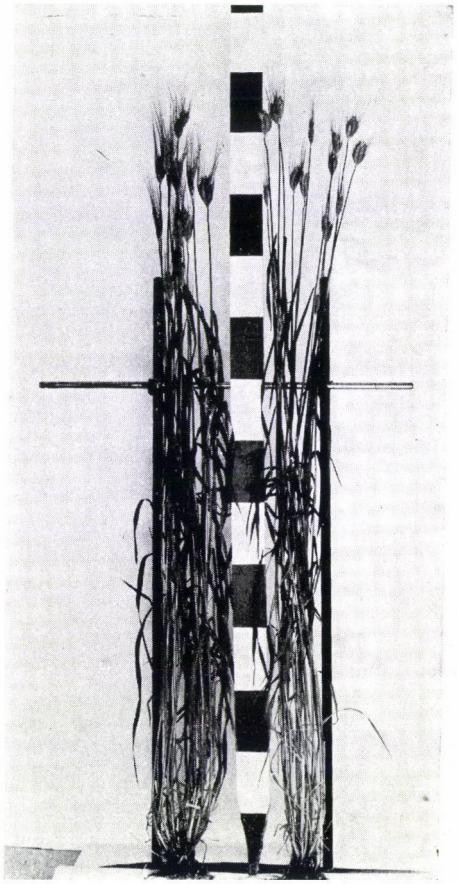

Fig. 2. Triticum timopheevi Zhuk. var. *compactum* Szalay

The Agricultural Research Institute of the Hungarian Academy of Sciences received seed of *T. timopheevi* Zhuk. var. *typicum* Zhuk. (var. *timopheevi* according to the present nomenclature) in 1950 from the collection of the All-Union Plant Growing Institute (VIR-Leningrad). The derivatives of this sample were sown every year at Martonvásár and used in interspecific and intergeneric Triticum crossing.

In 1961 a plant with compact, short and close-packed spikes was noticed in a *T. timopheevi* Zhuk. var. *timopheevi* plot (sown in pots on 20th September 1960, transplanted to the biological nursery on 26th November at a spacing of 30 × 30 cm).

The derivatives of var. *timopheevi* and the compact-spike variant were sown in autumn and spring at a spacing of 10 × 15 cm and followed with attention in the biological nursery of our Institute. After ripening the plants were pulled up and processed one by one. Values referring to the spike were averaged from the processing data of the main spikes of the plants. The value of compactness was calculated using the generally accepted formula

$$D = \frac{\text{total number of spikes} \times 100}{\text{length of the spindle in mm}}$$

Crossing was carried out in the usual way, under a cellophane isolator.

The compact-spike plant found in 1961 had a spike length of 5 cm, a compactness value of D = 44.0 and an average of 10.3 grains per spike. The typical plants in the same plot developed 8 cm long spikes with a compactness value of D = 27.3 and an average of 34.7 grains/spike. In the new form flowering began seven days later (on 19th June) than in the control (on 12th June).

In subsequent years the compact-spike plants steadily transmitted their characteristic type of spike. The original *T. timopheevi* Zhuk. var. *timopheevi* and the compact-spike variant — to which we gave the name *T. timopheevi* Zhuk. var. *compactum* Szalay (SZALAY 1964) — show a striking difference in the shape of the spike (Figs 1 and 2). Accordingly, there are considerable differences in the length of the spike and the value of compactness.

T. timopheevi Zhuk. var. compactum Szalay

T. Timopheevi var. *compactum* Szalay nova varietas est. Spicas habet flavescentes, planas, breves (35—50 millesimas metri partes longitudinis), densas spissasque (D = 45—70), parum pilosas, spinosas, fragiles. Gluma 11—14 millesimas metri partes longa est, umeri glumarum conspicui sunt, glumae rhachis in acus glumae 3—5 millesimas metri partes longum desinit. Caryopsis rufa, oblonga, paleis eximi difficilis est.

Characteristic data obtained for the two types in 1965 and 1975 are presented in Table 1. In 1965 — following an autumn sowing — the average length of the main spike was 7.5 cm in var. *timopheevi* and 4.2 cm in var. *compactum* Szalay. In 1975, in a spring sowing, the main spikes of var. *timopheevi* and var. *compactum* had an average length of 7.8 and 4.3 cm, respectively.

The average value of compactness was D = 31.4 in 1965 and D = 27.3 in 1975 for var. *timopheevi*, and 55.7 and 53.8, respectively, for var. *compactum* Szalay.

Var. *timopheevi* produced more grains in the main spike in both years ($\bar{x}$ = 37.1 in 1965 and 41.1 in 1975) than the compact form ($\bar{x}$ = 29.6 in 1965 and 33.5 in 1975). Var. *timopheevi* exceeded the new varieties in thousand-grain-weight as well (43.6 and 37.3 g in 1965 and 31.3 and 25.9 g in 1975).

As may be seen in Table 1, earing and flowering occurred later in var. *compactum* Szalay than in var. *timopheevi* in both years. As to the other features considered (plant height, number of spikes per plant) differences between the two types can be regarded as accidental.

The later flowering in the compact-spike plants decreases the probability of a spontaneous crossing of the two forms. Artificial crossing results in a lower grain setting percentage than in combinations within the species in general (Table 2). The average grain setting percentage of *T. timopheevi* Zhuk. var. *timopheevi* × var. *compactum* Szalay over six years was 11.2%. The probable explanation for this is that the spikes of tillers had to be castrated for this combination. In the reciprocal crosses 36.5% of the flowers became fertile. (Well-developed spikes were pollinated with the pollen obtained from the spikes of tillers.)

The first generation derived from crossing the two variants developed var. *timopheevi*-type spikes irrespective of the direction of crossing. The effect of the other parent — var. *compactum* Szalay — was felt in the length and compactness of the spike, though the latter values were but slightly modified (Table 3). In the years in which the investigations were carried out (1966, 1974) the spikes in the F_1 generation were shorter by an average of 0.5—0.9 cm than the spikes of var. *timopheevi*. The compactness of the hybrid spikes grew by an average value of 3—9 compared to this parent.

Table 1

Major characteristics of T. timopheevi Zhuk. var. timopheevi and var. compactum Szalay plants (Martonvásár, biological nursery)

	1965 (sowing: 17. 10. 1964)				1975 (sowing: 10. 3. 1975)			
	var. *timopheevi*		var. *compactum*		var. *timopheevi*		var. *compactum*	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Date of earing	13. 6.	—	17. 6.	—	10. 6.	—	19. 6.	—
Date of flowering	21. 6.	—	23. 6.	—	14. 6.	—	23. 6.	—
Plant height, cm	157.0	5.4	163.0	5.9	141.5	5.2	135.8	11.1
Number of spikes/plant	30.7	12.3	34.3	12.4	3.9	1.2	5.6	1.5
Spike length, cm	7.5	0.6	4.2	0.4	7.8	0.6	4.3	0.4
Number of spikelets/spike	23.4	2.5	22.9	2.1	21.4	1.1	23.2	2.3
Compactness of spike (D)	31.4	3.6	55.7	6.8	27.3	2.3	53.8	5.8
Number of grains/main spike	37.1	9.5	29.6	5.4	41.1	9.5	33.5	9.7
Thousand-grain-weight, g	43.6	5.8	37.3	3.1	31.3	3.2	25.9	4.1

Table 2

Crossing data of T. timopheevi Zhuk. var. timopheevi and var. compactum Szalay (Martonvásár, biological nursery)

		Number of flowers	Number of grains	Percentage grain setting
var. *timopheevi* ×				
var. *compactum*	1970	600	31	5.1
	1971	280	60	21.4
	1972	620	65	10.4
	1973	400	21	5.2
	1974	180	52	28.8
	1975	200	27	13.5
Total		2280	256	average 11.2%
var. *compactum* ×				
var. *timopheevi*	1970	540	194	35.9
	1971	140	67	47.8
	1972	800	380	47.5
	1973	760	114	15.0
	1974	—	—	—
	1975	200	136	68.0
Total		2440	891	average 36.5%

Table 3

Spike data of T. timopheevi Zhuk. var. timopheevi, var. compactum Szalay and their F_1 generations (Martonvásár, biological nursery)

Designation	n	Spike length, cm		Number of spikelets/spike		D-value		Number of grains/spike	
		$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Sown on 7. 10. 1965, harvested in 1966									
var. *timopheevi*	20	6.7	1.3	19.5	3.2	28.9	1.9	29.7	7.9
var. *timopheevi* × var. *compactum* F_1	17	6.1	0.7	22.2	2.9	34.5	11.8	35.5	8.6
var. *compactum* × var. *timopheevi* F_1	9	5.8	1.0	21.8	3.0	37.5	4.8	41.0	6.9
var. *compactum*	20	3.8	0.4	20.0	1.5	52.9	5.3	26.5	8.0
Sown on 27. 9. 1973, harvested in 1974									
var. *timopheevi*	13	8.6	0.7	21.3	2.1	24.1	1.9	36.7	4.5
var. *timopheevi* × var. *compactum* F_1	10	8.0	0.9	23.3	1.3	29.3	3.4	37.5	5.8
var. *compactum* × var. *timopheevi* F_1	18	8.1	0.5	21.9	1.9	26.9	2.8	37.3	4.1
var. *compactum*	8	4.8	0.7	22.5	0.9	47.4	9.0	34.2	5.1

Most spikes of the F_2 plants represented the var. *timopheevi* type with varying spike length and compactness. According to the results of our observations 5—15% of the plants in the second generation produce spikes more compact than D = 50 and can thus be regarded as belonging to the compact type.

In 1973 we were given the opportunity of sowing and observing the two varieties in question of *T. timopheevi* Zhuk. at the Moscow experimental station of the Central Botanical Garden of the Academy of Sciences of the Soviet Union. The var. *compactum* Szalay retained its characteristic shape of spike.

The compact-spike plant observed in 1961 is considered to have been a natural mutant. Its derivative, which steadily transmits its characteristic features, is regarded as a new variety of *T. timopheevi* Zhuk. On the basis of our investigations the new variety seems to be the result of a multifactorial recessive change.

MENABDE (1963) considers *T. timopheevi* Zhuk. var. *compactum* Szalay to be identical with *T. timopheevi* Zhuk. convar. (grex) *plano-supercompactum* Men. var. *rubro-compressum* Eritz. This latter constant form was selected by ERITZYAN (1939) from among the hybrids of *T. timopheevi* Zhuk. × *T. persicum* Vav. (syn.: *T. carthlicum* Nevski) var. *fuliginosum* Zhuk.

The spike of *T. timopheevi* Zhuk. var. *compactum* Szalay is similar to that of *T. militinae* Zhuk. et Migush. It is worth mentioning that under different conditions spontaneous mutants with similar spikes appeared which showed apparent difference only in the colour of the spike. (The spike of *T. militinae* Zhuk. et Migush. described as black by the authors was found to be dark brown at Martonvásár.)

There does not seem to be any justification for regarding this natural mutant selected in Moscow as a separate species. In our opinion it can be classified in this species under the name of *T. timopheevi* Zhuk. var. *militinae* Zhuk. et Migush.

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EFFECT OF SUBMERGENCE ON THE CHEMICAL CHANGES IN DIFFERENT RICE SOILS

III. Kinetics of K, Ca and Mg

In earlier communications (Mohanty—Patnaik 1975, 1976) kinetics of pH, Eh, C, N, P, Fe and Mn in different rice growing soils as a function of time of submergence were reported as quantified general functions. This paper deals with the transformations of K, Ca and Mg in these soils as a function of time of submergence.

The details of the soils studied and the technique of extractions of the incubated soils were reported earlier (Mohanty—Patnaik 1975). Potassium in the NaCl extract was determined colorimetrically (Snell—Snell 1949) and Ca and Mg by titration with versenate (Cheng—Bray 1951). The data were processed in IBM 1620 computer to fit the kinetics in linear, quadratic, logarithmic and exponential functions.

Table 1

Equations for change in NaCl extractable potassium with time of submergence in different soils

Soil No. (location and soil type)	Equations best fitted	'a'	'b'	'c'	R^2, %
5 (Berhampur, red loam)	$y = a + bt + ct^2$	26.58	−1.71	0.21	22.14
6 (Chakuli, red loam)	-do-	67.46	9.00	−1.75	61.15
12 (Cuttack, alluvial)	-do-	21.15	−2.63	0.30	21.48
14 (Kiyang, alluvial)	-do-	14.36	3.11	−0.63	93.11
15 (Kendrapara, alluvial)	-do-	27.89	−5.20	0.80	29.36
18 (Palur, black)	-do-	5.41	6.87	−0.97	91.45
20 (Keshpur, saline)	-do-	103.13	5.46	0.90	7.03
1 (Bhubaneswar, laterite)	$\ln y = b \ln (t + 1) + c[\ln (t + 1)]^2$	2.62	0.54	−0.28	29.46
2 (Sukinda, laterite)	-do-	3.03	0.06	−0.07	39.35
3 (Pattambi, laterite)	-do-	3.46	1.31	−0.63	57.93
4 (Mysore, laterite)	-do-	2.42	2.34	−1.12	95.98
7 (Parmanpur, red loam)	-do-	4.43	−0.05	−0.16	66.41
8 (Gamharipalli, red loam)	-do-	4.46	−0.19	0.002	24.75
9 (Chiplima, red loam)	-do-	4.20	0.63	−0.55	76.58
10 (Bargarh, red loam)	-do-	4.37	0.29	−0.40	81.77
11 (Barpali, red loam)	-do-	4.72	−0.16	0.12	51.80
13 (Sakshigopal, alluvial)	-do-	3.32	0.25	−0.13	42.12
16 (Bolangir, black)	-do-	4.04	0.20	−0.29	43.86
17 (Arkhabahali, black)	-do-	3.51	0.45	−0.31	28.36
19 (Nellore, black)	-do-	1.84	2.25	−0.99	73.20

In discussing the results obtained in these investigations, data in respect of the value of the parameters studied have not been presented to save space but have been stated in the text. Of the four functions fitted for each parameter, the one with the highest R^2 value has been selected and summary tables on these prediction equations have only been presented giving their nature 'a', 'b', 'c' and R^2 values.

Change in available K. Seven out of the 20 soils followed quadratic transformation of K as a function of time (Table 1). There was a rapid increase in available K during the first 10 days of submergence after which there was a marked decrease between 20—50 days followed by either no change or slight decrease. The values of available K at the end of the 70-day period in acid soils were found to be higher than those present initially. These soils had low organic matter.

The remaining 13 soils exhibited exponential pattern of K transformations where there was a gradual increase in available K up to 20 days of submergence followed by a gradual decrease up to 50 days after which there was either no change or a slight decrease. These soils, though varied widely in their physico-chemical properties, had, in general, moderate to high organic C and low CEC.

Table 2

Equations for change in NaCl extractable calcium with time of submergence in different soils

Soil No.	Equations best fitted	'a'	'b'	'c'	R^2, %
3	$Y = a + bt + ct^2$	208.63	−8.77	0.63	73.01
6	-do-	671.74	60.69	−10.43	90.76
7	-do-	340.25	300.20	−3.21	64.61
16	-do-	1972.01	107.38	−26.36	75.55
18	-do-	963.47	−268.45	244.85	91.37
20	-do-	531.87	−144.54	14.23	80.79
1	$Y = a + b \ln (t + 1) + c[\ln (t + 1)]^2$	125.40	−90.80	108.23	98.82
5	-do-	601.33	−246.14	51.20	70.99
8	-do-	1024.04	−454.10	153.80	90.04
9	-do-	968.13	−422.23	227.53	54.23
10	-do-	1058.73	131.88	70.16	79.45
12	-do-	892.16	−693.83	288.50	96.98
14	-do-	768.43	−378.32	643.98	92.51
15	-do-	998.68	−512.80	235.02	68.97
17	-do-	2137.56	−398.18	248.07	49.81
2	$\ln y = a + b \ln (t + 1) + c[\ln (t + 1)]^2$	5.92	−0.47	0.29	46.31
4	-do-	5.98	0.17	−0.23	87.59
11	-do-	6.29	0.12	−5.26	87.79
13	-do-	6.66	−0.32	0.20	18.12
19	-do-	6.43	0.90	−0.44	91.69

Change in available Ca. In six soils which showed quadratic type of transformations, available Ca increased during the first 10—20 days of submergence followed by a gradua, decrease. In 10 soils which followed logarithmic transformations there was marked decrease in available Ca during the first 20 days of submergence and then it remained more or less constant. In 5 soils showing exponential transformation, there was a gradual increase during 30—50 days of submergence followed by a gradual decrease.

Change in available Mg. More than 50 per cent of the soils (11 soils) showed logarithmic type of change in available Mg. In these soils, the availability decreased slowly up to 10 to 20 days after submergence after which there was an increase up to 50 days of submergence followed by a decrease. Six soils showed a quadratic type of change in available Mg where the availability decreased sharply up to 10 to 20 days after submergence after which it increased up to 70 days. Soils 14, 17 and 20 showed an exponential type of change in available Mg where the availability increased up to 20—30 days after submergence and after that there was either a small decrease or increase.

The increase in K, Ca and Mg availability might be due to displacement of the ions from the soil complex and also to secondary effect of submergence (PEARSALL 1950, PONNAMPERUMA 1964). After reaching a peak, there was a reduction in the availability of K which

Table 3

Equations for change in NaCl extractable magnesium with time of submergence in different soils

Soil No.	Equations best fitted	'a'	'b'	'c'	R^2, %
1	$Y = a + bt + ct^2$	116.24	−55.44	98.15	90.35
2	-do-	117.40	−52.11	9.22	81.86
7	-do-	97.70	2.97	0.13	32.01
13	-do-	363.31	−24.96	6.01	89.13
15	-do-	330.55	32.58	−2.34	44.69
18	-do-	1004.28	141.00	−13.00	72.54
3	$Y = a + b \ln (t + 1) + c [\ln (t + 1)]^2$	96.85	−20.18	15.07	58.21
4	-do-	874.80	−286.66	129.97	85.16
5	-do-	18926.33	−28698.57	9819.51	92.90
6	-do-	180.48	−72.37	29.50	76.12
8	-do-	246.51	−144.80	47.15	93.78
9	-do-	200.02	−127.77	66.98	63.15
10	-do-	180.57	−76.68	32.34	47.92
11	-do-	20.49	183.42	67.50	69.73
12	-do-	243.23	44.52	33.18	78.21
16	-do-	336.56	−50.02	32.79	35.51
19	-do-	1541.31	−597.24	318.60	69.09
14	$\ln y = a + b \ln (t + 1) + c[\ln (t + 1)]^2$	6.75	0.31	−0.08	67.57
17	-do-	5.78	0.45	−0.08	98.94
20	-do-	6.99	0.51	−0.57	86.61

might be due to lattice fixation as illite was the dominant clay mineral in these soils (MOHANTY *et al.* 1974). Reduction in Ca and Mg availability during the course of submergence might have been due to the precipitation of these cations as carbonates or carbonate-apatites. The results, however, indicated no definite relationship of the transformations of these cations with the initial edaphic factors.

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OBSERVATIONS ON THE SHELTER-BELT PLANTED AROUND THE DANUBE CEMENT WORKS (NEAR VÁC, HUNGARY)

Dust pollution has various effects. By coating plant surfaces dust decreases the aesthetic value of the vegetation. Dust-coated plant surfaces have a reduced capacity for evaporation, so the surface may warm up to a higher degree and the excess heat may cause leaf necrosis.

The danger presented by dust also depends on its chemical composition (VÁSÁRHELYI 1970, KELLER 1973, KNABE 1973, SZILÁGYI 1973). The dangerous nature of loose cement dust in the vicinity of cement works — for the sake of accuracy: the loose dust from cement works — is assessed differently by various authors (PAJENKAMP 1961, SCHEFFER *et al.* 1961). They all agree, however, that the harm caused by loose dust from cement works is primarily due to the CaO and other metallic oxides it contains (ARDELAN *et al.* 1970, CZAJA 1962a, b, c). The extent of dust damage is also influenced by meteorological factors (PAJENKAMP 1961, BOHNE 1963, CZAJA 1962a, b, c).

When the loose dust from cement works settles on a wet plant surface its high CaO content makes it act as a caustic. The humidity also causes the cement powder contained in the dust to set, thus producing an alkali with a high pH-value (pH = 8 — 12) (CZAJA 1962b). This alkali reaches the parenchyma cells, which have a high chlorophyll content, either by destroying the epidermis or by penetrating through the stomata. By dehydrating the cells the alkali destroys the components of the living protoplasm, including the chlorophyll (CZAJA 1962a, b, c, 1966), thus resulting in a reduced amount of chlorophyll in the leaves. The change in the chlorophyll content is easy to measure; it has been found to be proportionate to the extent of pollution (KOVÁCS—KLINCSEK 1974). The affected plants have a reduced function and their development is hindered.

Besides the meteorological factors, the extent of damage also depends on the specific characteristics of the plant (KOVÁCS—KLINCSEK 1974). The sensitivity of pine trees to dust damage is emphasized, for instance, by a number of authors (WOLF, cit. PAJENKAMP 1961, CZAJA 1962c), but investigations made in Hungary do not confirm this statement (KOVÁCS—KLINCSEK 1974).

When planting protective forests around industrial establishments it may be important to know the sensitivity of the tree species. Almost simultaneously with the establishment of the Danube Cement Works (1961) an experimental shelter-belt composed of a variety of tree species was planted in the neighbourhood, which has since reached a certain level of development.

The immediate vicinity of the cement works "ensured" constant pollution. On the affected area the different tree species of the shelter-belt showed various rates of development. The actual volumes of the different tree species were determined in order to discover which of them was able to grow, in spite of the constant pollution, into really high, crowned trees serving as active natural dust screens, and to show a satisfactory annual growth in the relatively short time preceding the investigations.

Table 1

Growth rate in some major tree species
(Source: 1965 data of the Chief Administration of Forestry)

Species	Age, years	Height, m		Trunk diameter, cm (at breast height)	
		class		class	
		I	III	I	III
Oak (from Z. Fekete, partly revised)	5	—	—	—	—
	10	2.6	1.7	—	—
	15	—	—	—	—
	20	6.9	4.1	5.6	2.7
Oak (according to Greiner)	5	1.5	1.0	—	—
	10	4.3	3.0	—	—
	15	7.1	5.3	6.0	4.8
Poplar (according to Magyar)	5	9.1	6.6	3.4	2.3
	10	17.8	13.6	11.9	9.3
	15	24.6	19.2	23.1	18.2
Scotch fir (according to Greiner)	5	1.0	0.8	—	—
	10	2.6	2.0	—	—
	15	4.8	3.9	4.4	3.5
Larch (according to Greiner)	5	2.0	1.6	—	—
	10	4.5	3.5	—	—
	15	7.0	5.3	5.3	4.4

No material of identical or nearly identical age and composition planted under similar ecological conditions was available as a control, so comparison with an unpolluted area was not possible. The average growth of some major tree species at forest sites of classes I and III in Hungary are shown in Table 1 as a guide (Chief Administration of Forestry 1965).

The growth of plants, and particularly of trees, depends to a large extent on climatic factors, particularly on the annual amount and distribution of precipitation. A comparison between annual data on climatic elements (primarily on precipitation) and the growth of the trees would have made it possible to decide to what extent the reduced growth of the different species was due to dust pollution; however, the Vác station of the Hungarian Central Meteorological Office ceased to function in the fifties, so the necessary data were not available.

Parameters obtained for different species under identical conditions, however, gave sufficient information on their behaviour.

The total reactions, the actual growth shown by a plant under the local ecological conditions in a given time (in the present case 12 years), are important criteria of the plant's behaviour, since they reflect the actual situation. Measurements were therefore made on the actual height, trunk diameter and annual extent of lateral growth for the tree species occurring most frequently on the area concerned. The measurements were carried out at the end of the winter, when the trees were still in a dormant state and thus easily accessible, and the annual growth could be clearly distinguished.

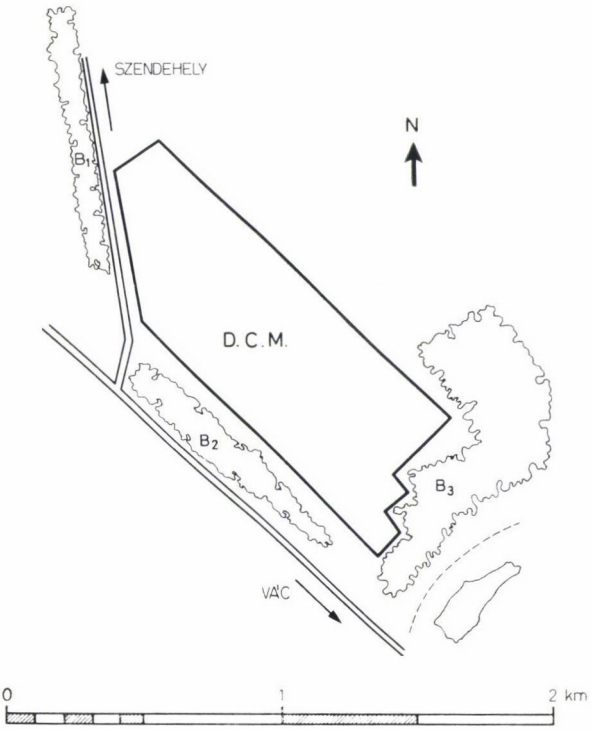

Fig. 1. Sampling places in the shelter-belt surrounding the Danube Cement Works; voluminal increase 1973 (B_1, B_2, B_3: highly polluted forest zones)

The heights of the trees were measured with a "Chrysten" device, which is also used in forestry, with the aid of a four metre long auxiliary lath. The trunk diameter was measured — in contrast to the practice in forestry — at the base, using a slide-gauge or folding rule. (This was because the trees of some species often did not even reach breast height.) The annual extent of lateral shoot growth, which partially expresses the so-called viability, was measured on three different sides using a folding rule in shoots growing at breast height on broad-leaved trees and pines. In the case of trees which did not reach breast height or had no shoots at that height we measured the nearest measurable shoots. The length of one-year old shoots was taken as the distance from the base of the shoot to that of the terminal bud.

In the three sampling areas around the Danube Cement Works, trees from the highly polluted forest belt (Fig. 1) were chosen for examination at random. Ten height and ten trunk diameter measurements were taken for each sampling place and species. The annual lateral growth was averaged on the basis of 30 data. In the area of investigation the following 15 tree species were examined: *Acer pseudoplatanus*, *Aesculus hippocastanum*, *Cerasus avium*, *Crataegus monogyna*, *Elaeagnus angustifolia*, *Koelreuteria paniculata*, *Larix decidua*, *Pinus nigra*, *Pinus silvestris*, *Populus robusta*, *Pseudotsuga menziesii*, *Quercus petraea*, *Quercus robur*, *Sophora japonica* and *Tilia cordata*.

Under the influence of 12 years of permanent pollution by loose dust from cement works the development of the 15 tree species examined, which were grown on hill-side loess (with a forest-steppe climate) showed considerable variation and only partly fulfilled the expectations, as shown by a detail of the experimental shelter-belt (Fig. 2).

Fig. 2. Part of the material from experimental shelter-belt around the Danube Cement Works

Only four of the species examined reached a height of at least 5 m (remarkably few in a closed forest plantation). These were *Populus robusta*, *Cerasus avium*, *Elaeagnus angustifolia* and *Pinus silvestris*. Only seven species — *Populus robusta*, *Cerasus avium*, *Elaeagnus angustifolia*, *Pinus silvestris*, *Pinus nigra*, *Koelreuteria paniculata* and *Crataegus monogyna* — achieved the height characteristic of the species.

On the basis of absolute height and trunk diameter data it is possible to select tree species suitable for planting on areas damaged by cement dust; this seems to be confirmed by the so-called viability figures, i.e. the averages of lateral growth, though owing to the wide deviations the latter data can only be taken into consideration to a limited extent. The absolute height, trunk diameter and viability data for the material examined are shown in an order of increasing value by Figs 3, 4 and 5.

On the basis of the investigation it can be stated that on a hilly area with a loess bed, under forest-steppe climatic conditions, in an environment polluted by loose dust from cement works, the tree species *Populus robusta*, *Cerasus avium*, *Elaeagnus angustifolia* and *Pinus silvestris* are excellently suited for the establishment of a green belt. *Pinus nigra*, *Koelreuteria paniculata* and *Quercus robur* also show satisfactory development. The resistance of pine trees, especially of *Pinus silvestris*, is remarkable in this area, in contrast to West-European literary data. This points to the hardier nature of Scotch fir populations in Hungary (Fig. 6) and to the peculiarities of Hungarian weather conditions.

Quercus petraea, *Pseudotsuga menziesii*, *Sophora japonica*, *Acer pseudoplatanus* and *Aesculus hippocastanum* are not recommended for afforestation in the vicinity of cement works.

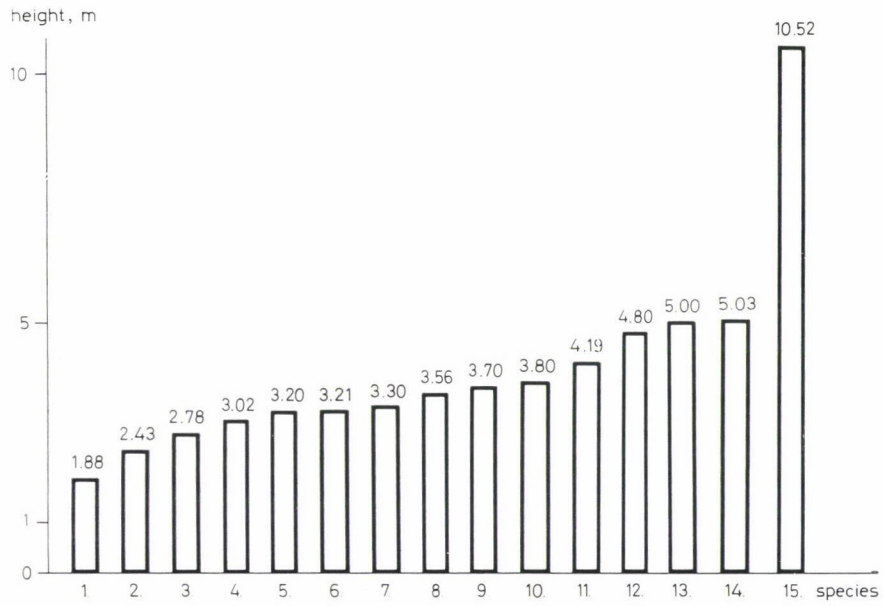

Fig. 3. Actual average height (m) of tree species growing in a highly polluted environment (12-year-old stand). (1. *Quercus petraea*, 2. *Pseudotsuga menziesii*, 3. *Sophora japonica*, 4. *Crataegus monogyna*, 5. *Aesculus hippocastanum*, 6. *Tilia cordata*, 7. *Pinus nigra*, 8. *Quercus robur*, 9. *Koelreuteria paniculata*, 10. *Larix decidua*, 11. *Acer pseudoplatanus*, 12. *Pinus silvestris*, 13. *Elaeagnus angustifolia*, 14. *Cerasus avium*, 15. *Populus robusta*)

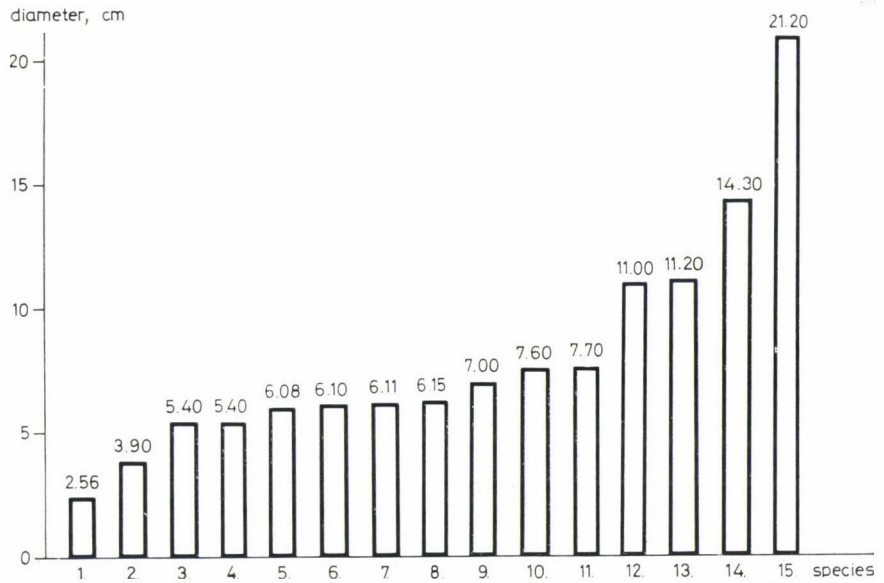

Fig. 4. Average trunk diameters (cm) measured at the base, attained in 12 years by tree species growing on an area heavily polluted by cement dust. (1. *Quercus petraea*, 2. *Pseudotsuga menziesii*, 3. *Sophora japonica*, 4. *Acer pseudoplatanus*, 5. *Larix decidua*, 6. *Crataegus monogyna*, 7. *Tilia cordata*, 8. *Aesculus hippocastanum*, 9. *Quercus robur*, 10. *Koelreuteria paniculata*, 11. *Pinus nigra*, 12. *Pinus silvestris*, 13. *Cerasus avium*, 14. *Elaeagnus angustifolia*, 15. *Populus robusta*)

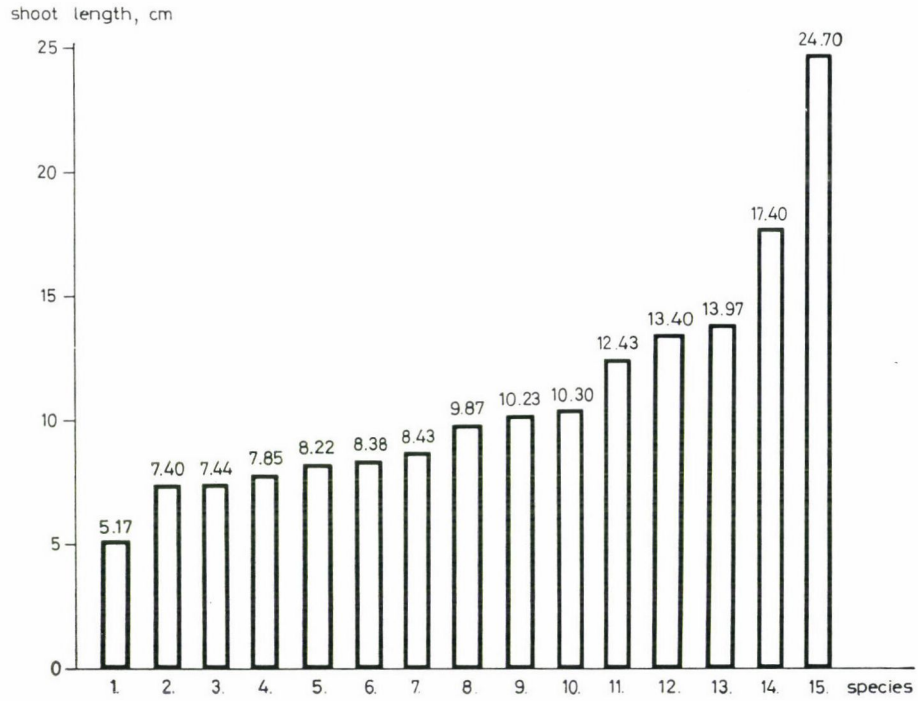

Fig. 5. Average lateral growth (cm) in 1973 for tree species growing on an area highly polluted by cement dust. (1. *Aesculus hippocastanum*, 2. *Sophora japonica*, 3. *Acer pseudoplatanus*, 4. *Quercus petraea*, 5. *Larix decidua*, 6. *Tilia cordata*, 7. *Cerasus avium*, 8. *Populus robusta*, 9. *Crataegus monogyna*, 10. *Koelreuteria paniculata*, 11. *Pinus nigra*, 12. *Pseudotsuga menziesii*, 13. *Quercus robur*, 14. *Pinus silvestris*, 15. *Elaeagnus angustifolia*)

Fig. 6. Well developed Scotch firs *(Pinus silvestris)* in the shelter-belt around the Danube Cement Works

It has been observed phytogeographically that the tree species suitable for afforestation are either those once native on the area (e.g. *Cerasus avium*, *Quercus robur*) or tree species of high ecological adaptability (e.g. *Populus robusta*, *Koelreuteria paniculata*, *Pinus nigra*, *Elaeagnus angustifolia*). The tree species not recommended for afforestation either show a low ecological adaptability or are not natives of the area.

Horticulture and forestry, however, require a wider range of species and varieties. Therefore, in order to widen the assortment further species should be included in comparative trials, and further, quicker methods of examination, giving the possibility of extrapolation, should be elaborated, tested and applied.

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RESPONSE OF SOYABEAN TO RATES OF NITROGEN AT G.R.S., SUDAN

ABEL (1963) stated that applying no nitrogen at the Imperial Valley of California permitted better nodulation and higher seed yields than the application of 112.05 kg of nitrogen at planting time. IGNATIEFF—POGE (1958) reported that soyabean often responded to nitrogen application especially in the earlier stages of growth. MORSE (1950) mentioned that soyabean showed an indifferent response to direct fertilization application when grown in more produc-

tive soils. CARTTER—HOPPER (1942) concluded that marked soyabean yield variations were stimulated by differences in natural productivity of soil management. Increased oil content of beans was reported by ADAMS *et al.* (1937) with application of a combination of potassium and nitrogen.

The experiment described in this paper evaluated the effects of nitrogen application to soyabean and the feasibility of raising soyabean commercially in Sudan.

Three soyabean varieties — Hill, Lee and Dare, belonging to the maturity groups V, VI and VIII respectively — were planted on 1/6 at G.R.S., Medani, Sudan, for the seasons 1968/69 and 1969/70, following cotton in rotation. The type of soil is heavy, dark cracking clay with a pH of about 8.5 and a low nitrogen status (about 0.025 per cent). The average annual rainfall was 300 mm.

Planting was at a spacing of 60 cm between ridges, 15 cm between holes and with two seeds per hole. On the same day of planting the seeds were inoculated with the soyabean nodulating bacterium, *Rhizobium japonicum*. The soyabean crop was irrigated at two weeks intervals and was weeded twice.

Three levels of nitrogen fertilizer were tested (zero, 44.82 and 89.65 kg N per ha). The fertilizer, urea, was applied at sowing and as side-dressing. The design of the experiment was a randomized block replicated six times and the sub-plot was 15 m × 3.6 m. Each sub-plot was split into two parts, the northern part for growth analysis sampling and the southern part was reserved for final yield evaluation. Sampling started two weeks after planting, proceeding at two weeks intervals and consisted of taking randomly a half running meter plant sample per sub-plot. Leaf area determination was based on the punch borer method (NUR 1971).

The distance from soil surface to the first pod-bearing node was taken at harvest time and was denoted as the height of the first productive node. This height is of importance if the crop is to be mechanically harvested as any cluster of pods located below the cutting bar height is likely to be lost in harvest.

Oil content was conducted by the laboratory press method (NUR 1973).

All the operations from seeding to harvesting were manually done.

The combined analysis of variance results for the two seasons (1968/69—1969/70) contained in Table 1 shows that soyabean crop responded to nitrogen fertilization in all characters studied except height of the first productive node, number of nodules per plant and oil percentage. Though there were no significant differences between the three varieties at each nitrogen level, each variety resulted in higher yields of fully rounded mature seeds with each additional fertilizer level. The increase in seed yields from zero N to 89.65 kg N per ha were 47%, 52% and 46% for Dare, Lee and Hill respectively.

As for the percentage of green seeds found at harvest time, omitting nitrogen had the least green seeds whereas 89.65 kg N resulted in the greatest percentage of green seeds.

Thickness of the main stem at the first node, that was taken at harvest time, reflected the same situation as the above two items, i.e. plants receiving 89.65 kg N had the greatest stem thickness whereas those with zero N had the thinnest stems. Among other factors such as the number of leaves, branches, pods etc. that contribute to greater dry matter production, thickness of the main stem was found to be a factor which showed a significant difference between the treatments tested.

Leaf Area Duration calculated for the period between flowering and ripening — the period providing most of the dry matter in the seed — increased by each additional dose of nitrogen for each of the three varieties.

Maximum L.A.I. was affected by the application of nitrogen. Maximum L.A.I. values increased with each additional nitrogen level.

The values obtained for the integrated L.A.D. from flowering to maturity and maximum L.A.I. fully support the final seed yield results. Though soyabean is a legume crop, it did re-

Table 1

Effect of nitrogen fertilizer on some soyabean characters studied at G.R.S., Sudan

Variety	Nitrogen level			Variety	Nitrogen level		
	Zero N	44.82 kg/ha N	89.65 kg/ha N		Zero N	44.82 kg N	89.65 kg N
	Mature seed yield (kg/ha)				Integrated L.A.D. from flowering to maturity		
Dare	185.33	227.34	271.82	Dare	1.10	1.73	2.53
Lee	165.56	200.16	252.05	Lee	0.85	1.51	2.26
Hill	195.22	229.81	284.17	Hill	1.18	1.80	2.61
S.E. ± 11.91	C.V. = 14.2%			S.E. ± 0.20	C.V. = 10.9%		
	Percentage green seeds				*Height of the 1st productive node (cm)*		
Dare	50	54	58	Dare	5.2	5.2	5.2
Lee	47	51	57	Lee	5.0	5.1	5.0
Hill	51	54	60	Hill	4.9	5.0	5.0
S.E. ± 0.98	C.V. = 7.8%				C.V. = 10.4%		
	Thickness of the main stem at the first node (mm)				*No. of nodules per plant (at harvest)*		
Dare	10.2	12.7	15.1	Dare	3.0	2.8	3.1
Lee	9.3	11.7	14.3	Lee	2.6	2.5	2.7
Hill	10.0	12.4	15.3	Hill	2.8	3.0	2.9
S.E. ± 0.83	C.V. = 6.5%				C.V. = 9.3%		
	Maximum L.A.I.				*Oil percentage*		
Dare	0.73	1.08	1.46	Dare	25.1	25.0	25.1
Lee	0.61	0.96	1.31	Lee	25.3	25.2	25.0
Hill	0.81	1.15	1.59	Hill	25.0	25.0	25.1
S.E. ± 0.11	C.V. = 8.7%				C.V. = 6.1%		

spond to the addition of nitrogen fertilizer. This might be due to the limited number of nodules produced by the soyabean plants (Table 1).

The production of a successful crop of soyabean in Sudan presents many problems which are not usually found in other countries. The consistently poor yields and high seed shattering obtained in this experiment and in other experiments conducted in different areas of Sudan are never comparable to any soyabean producing area. As shown in Table 1 the seed yield is markedly low and the percentage of green and shrivelled seeds is very high, both will result in negative economic returns.

Soyabean is a classical crop with respect to photoperiodism and because of this it is divided into different maturity groups (00—VIII) based on latitude; daylength is a function of latitude.

The site where this experiment was conducted lies in latitude 15°N where day and night hours are equal and where it has never been known to have adaptable soyabean varieties or to be adapted for soyabean production. It was noticed that all the soyabean varieties tested in Sudan resulted in plants with determinate flowering whereas they are supposed to be indeterminate. Unless soyabean varieties belonging to groups IX and X are produced, Sudan will never be a soyabean producing country.

The results of this study indicate the response of soyabean to nitrogenous fertilizer. There was a significant increase with each additional nitrogen level in the case of seed yield, percentage green seeds, thickness of the main stem at the first node and in growth analysis parameters. The addition of nitrogen to soyabean had no effect on the height of the first productive node, number of nodules per plant and oil content.

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CRITICAL LIMIT OF AVAILABLE ZINC WITH DIFFERENT EXTRACTANTS FOR LENTIL (LENS ESCULENTA L.) IN TARAI SOILS

No work has yet been done on the interpretation of soil analysis data on zinc in Tarai* soils. The most important aspect in this interpretation is how to predict the probability of getting a profitable response to the application of zinc fertilizer. The soil-test interpretation studies under the International Soil Fertility Evaluation and Improvement Programme envi-

* Foot-hills of the Himalayas.

sage setting up a "critical limit" below which economic responses are possible. CATE—NELSON (1965) have described a rapid method for the correlation of soil test data with plant responses.

Laboratory and potted plant studies based on the above principles were conducted on 20 soils collected from the Tarai region of Nainital (U.P.), India, in order to correlate zinc status with lentil crop responses.

Bulk samples of ploughed-layer soils were collected from 20 sites in the Tarai region of Nainital. The soils were air-dried and ground with a wooden roller. Some soil characteristics pertinent to this investigation were determined as follows: sand, silt and clay by the International pipette method, pH in a 1 : 2 soil to water suspension with a Beckman pH meter, calcium carbonate by the rapid titration method, organic matter according to Walkley and Black's method and total zinc as described by BLACK (1965).

Available zinc was determined in the extract by the dithizone method (BLACK 1965) after extracting zinc with five extractants, viz. (a) 0.05 N hydrochloric acid + 0.025 N sulphuric acid, (b) 0.005 M diethylene triamine penta-acetic acid (DTPA) + 1.0 M ammonium carbonate, (c) 0.01 per cent dithizone + 1.0 N ammonium acetate (pH 7.0), (d) 1.0 N ammonium acetate (pH 4.6) and (e) 2 N magnesium chloride.

Green-house studies: Ten kg soil was placed in each of the plastic pots used in the experiment. Basal doses of phosphorus and potassium were applied at a rate of 40 ppm P and 30 ppm K per pot. 0.4 and 8 ppm zinc were used as graded zinc levels to study responses to applied zinc. A leguminous crop, lentil (*Lens esculenta* L. variety T-36), was grown for 75 days. The pots were maintained at field capacity with distilled water. The plants were harvested at the end of the growth period, washed, and dried in an oven at 60°C to constant weight.

The dry matter yield from the no zinc treatment was calculated as a percentage of the highest yield for each soil, and the data were plotted against the soil test values for the five extractants separately. CATE and NELSON's (1965) technique was employed to separate the results into quadrants and to indicate the critical level of zinc for the test used.

The physical and chemical characteristics of the twenty soils are presented in Table 1.

In general all the soils were of medium texture. Based on mechanical analysis data, nine soils (soil numbers 4, 5, 6, 7, 10, 11, 13, 15 and 19) were silt loam, five were loam (soil numbers 1, 3, 8, 12 and 14) and three were loamy sand (soil numbers 16, 17 and 20). The remaining three, that is soil numbers 2, 9 and 18, were clay loam, silt and silty clay loam, respectively. Most of the soils studied had more than 40 per cent sand.

According to the classification of pH made by MUHR *et al.* (1965), most of the soils could be grouped under the normal range, except soil numbers 4, 7, 9 and 10, which could be placed as tending towards the alkaline range. The pH of these twenty soils varied from 7.3 to 8.8.

The organic matter content of these twenty surface soils varied from 1.56 to 2.96 per cent. However, fifteen out of the twenty soils had a content of 2 per cent or more.

The calcium carbonate content of the soils varied from trace to 8.88 per cent. Fifteen out of twenty soils contained less than 4.0 per cent calcium carbonate, while the remaining five soils contained more than 4.0 per cent calcium carbonate.

The total zinc content of the soils varied from 12.0 ppm (soil number 10) to 40.5 ppm (soil number 7). Sixteen out of twenty soils contained more than 20 ppm total zinc, while the remaining four contained less than 20 ppm total zinc.

Amount of available zinc extracted by five zinc extractants and factors affecting the extractability of soil zinc. The amount of zinc extracted by the dilute (hydrochloric—sulphuric acid) acid mixture was more than that by other extractants. This was followed by chelating agents (DTPA-ammonium carbonate and dithizone), ammonium acetate (pH 4.6) and magnesium chloride in their capacity to extract soil zinc. The dilute acid mixture extracted 1.1 to 5.4 ppm zinc in different soils (Table 2). The average for all twenty soils was 2.34 ppm. Of the chelating agents, DTPA-ammonium carbonate extracted a greater amount of zinc, and

Table 1

Physical and chemical characteristics of the surface soils

Soil number	Soil pH	Total zinc (ppm)	Organic matter (per cent)	Calcium carbonate (per cent)	Sand (per cent)	Silt (per cent)	Clay (per cent)	Textural class
1	8.3	38.0	1.82	0.55	59.2	24.4	16.4	Loam
2	7.9	19.5	1.56	0.46	49.5	25.3	25.0	Clay loam
3	7.8	29.0	2.34	0.04	58.4	22.5	18.8	Loam
4	8.6	21.5	2.60	4.69	54.2	39.0	6.5	Silt loam
5	8.3	21.0	2.86	4.28	50.9	32.5	16.2	Silt loam
6	8.4	24.0	2.44	4.11	48.4	34.6	18.0	Silt loam
7	8.6	40.5	2.08	4.40	43.4	39.8	16.5	Silt loam
8	8.2	22.0	2.76	2.53	60.0	22.6	17.2	Loam
9	8.8	35.0	2.03	2.41	31.8	53.4	14.3	Silt
10	8.7	12.0	2.70	8.88	41.0	35.8	22.8	Silt loam
11	8.3	15.0	2.39	2.20	48.0	30.5	21.4	Silt loam
12	7.9	32.5	1.61	0.21	64.4	23.3	12.0	Loam
13	8.1	19.0	2.06	0.71	50.8	41.3	7.5	Silt loam
14	7.9	31.0	1.82	Trace	53.8	32.5	13.5	Loam
15	7.8	34.0	2.13	0.46	43.7	38.5	16.8	Silt loam
16	7.5	37.0	2.03	0.08	66.4	22.8	10.5	Loamy sand
17	7.3	27.5	2.65	Trace	68.3	20.4	10.8	Loamy sand
18	7.8	23.0	2.76	0.33	40.4	30.9	28.1	Silty clay loam
19	7.7	37.5	2.96	1.04	47.3	32.5	20.0	Silt loam
20	7.3	23.5	1.82	Trace	69.5	19.4	11.0	Loamy sand

the range was 1.10 to 4.20 ppm with an average of 2.02 ppm. The zinc extractable with dithizone varied from 0.20 to 2.50 ppm, and the average was 1.09 ppm. The zinc extracted by ammonium acetate (pH 4.6) varied from 0.20 to 1.95 ppm with an average of 0.88. Of all the extractants tested magnesium chloride gave the lowest amount of extractable zinc, ranging from 0.15 to 1.90 ppm with an average of 0.78 ppm. Depending upon the magnitude of zinc extraction, these extractants could be arranged in descending order as follows: dilute (hydrochloric–sulphuric) acid mixture > DTPA-ammonium carbonate > dithizone > ammonium acetate (pH 4.6) > magnesium chloride.

Negative correlations were found between the zinc extracted by various extractants and the soil pH or the calcium carbonate content of the soils (Table 3). These negative correlations might be due to the presence of insoluble calcium zincates. This form of zinc could not be extracted by the extractants, thus leading to a negative correlation. From the "r" values obtained, it was quite obvious that extraction by many extractants was mainly affected by the pH and the calcium carbonate content of the soils. The "r" values for calcium carbonate were non-significant, but since they approached the level of significance, calcium carbonate had some

Table 2

Zinc extracted (ppm) from the soils with various extractants

Soil number	0.05 *N* hydrochloric acid + 0.025 *N* sulphuric acid	0.005 *M* DTPA + 0.01 *M* TEA buffer + 0.01 *M* calcium chloride + 1.0 *M* ammonium carbonate	0.01 per cent dithizone + *N* ammonium acetate	*N* ammonium acetate (pH 4.6)	2 *N* magnesium chloride
1	1.75	1.65	0.75	0.70	0.60
2	1.25	1.40	0.40	0.40	0.25
3	1.10	1.20	0.45	0.35	0.30
4	1.35	1.15	0.30	0.30	0.20
5	1.55	1.30	0.25	0.20	0.15
6	1.85	1.60	0.50	0.40	0.35
7	1.95	1.65	0.55	0.45	0.40
8	1.80	1.50	0.35	0.30	0.25
9	1.40	1.10	0.20	0.35	0.15
10	2.25	2.10	1.80	1.60	1.25
11	1.50	1.15	0.50	0.35	0.40
12	5.40	4.20	2.50	1.80	1.90
13	4.55	3.85	2.00	1.50	1.40
14	1.90	1.25	0.80	0.75	0.55
15	2.35	1.80	1.70	1.05	0.95
16	2.60	2.00	1.25	0.95	0.75
17	4.10	3.50	2.35	1.95	1.85
18	3.95	3.25	2.25	1.85	1.80
19	2.25	2.50	1.50	1.25	1.10
20	1.90	2.15	1.35	1.10	0.90

influence on soil zinc extraction. However, the extent of this influence was less than that of the soil pH, since the soil pH gave significant "r" values with most of the extractants. The silt content gave a negative but non-significant correlation with the extractable zinc. The reason for this may be the presence of calcium carbonate in the silt fraction of the soils. The sand content gave a positive but non-significant correlation with the extractable soil zinc. These types of relationship between silt/sand and extractable zinc were also obtained by VITTAL (1971).

The clay content gave a non-significant negative correlation with the extractable soil zinc. With many extractants, the "r" values were of a very low order, which indicated that the clay content did not affect soil zinc extraction with these extractants. The organic matter content also gave non-significant correlations with most of the extractants, except with the dilute (hydrochloric–sulphuric) acid mixture, where the "r" value was highly significant. Such a highly significant negative correlation value indicated that the soil zinc extraction with the dilute acid mixture was strongly affected by the organic matter content of these soils.

Symptoms of zinc deficiency in lentil. The following deficiency symptoms were recorded in lentil plants after 50 days' growth.

1. The middle leaflets showed a fading of the green colouration, followed by the development of a yellowish orange pigmentation.

Table 3

Simple correlation coefficients (r) between physico-chemical properties of the soil and zinc extracted by various extractants

Zinc extracted by	Property						
	pH	Total zinc	Organic matter	Calcium carbonate	Clay	Silt	Sand
0.05 *N* hydrochloric acid + 0.025 *N* sulphuric acid	−0.361	+0.039	−0.854**	−0.302	−0.307	−0.139	+0.223
0.005 *M* DTPA + 0.01 *M* TEA buffer + 0.01 *M* calcium chloride + 1.0 ammonium carbonate	−0.444	+0.012	−0.111	−0.424	−0.243	−0.255	+0.231
0.01 per cent dithizone + *N* ammonium acetate	−0.512*	+0.013	−0.043	−0.275	−0.098	−0.224	+0.185
N ammonium acetate (pH 4.6)	−0.483*	−0.012	+0.134	−0.224	−0.038	−0.202	+0.018
2 *N* magnesium chloride	−0.484*	−0.001	+0.133	−0.269	−0.058	−0.233	+0.203

* Statistically significant at the 5% level.
** Statistical significant at the 1% level.

Table 4

Dry weight of lentil shoot (g per pot) under different treatments and percentage or relative yields

Soil number	Zinc added to soils (ppm)			Percentage or relative yield
	0.0	4.0	8.0	
1	3.27	8.05	5.20	40.62
2	4.26	5.07	7.07	60.25
3	4.13	6.63	5.79	62.29
4	2.06	1.45	3.71	55.52
5	4.19	4.71	6.04	69.37
6	3.51	2.45	4.90	71.63
7	4.70	2.63	4.11	100.00
8	3.31	5.52	5.53	59.85
9	2.72	6.35	5.11	42.83
10	6.71	4.45	2.52	100.00
11	3.71	3.54	5.93	62.56
12	5.12	2.63	4.92	100.00
13	6.30	2.68	6.26	100.00
14	3.30	4.50	2.52	73.33
15	5.91	2.44	8.50	69.53
16	7.90	8.15	7.45	96.93
17	5.43	6.71	6.50	80.92
18	4.32	2.71	4.05	100.00
19	8.11	7.92	7.13	100.00
20	7.90	4.94	5.99	100.00

2. The size of the lamina was reduced.

3. Premature shedding of the severely affected leaflets, first of the middle leaves and then of the young leaves, was also observed.

Such symptoms appeared in eleven of the twenty soils studied, while the remaining nine soils (soil numbers 10, 12, 13, 15, 16, 17, 18, 19 and 20) did not show any symptoms. These symptoms were only observed in plants grown as controls (without added zinc).

Critical limits of available zinc in soils for lentil crop. The scatter diagram method, as described by CATE—NELSON (1965), was used to discover the critical limits of zinc in these soils.

The soil test values (Table 2) and the percentage yield (Table 4) were plotted on the X and Y axes (Fig. 1) for different extractants. One of the chief aims in attempting to relate the percentage yield to soil test values in this way was to find the point of inflexion on the curve (termed "Critical soil test limit or value") below which the probability of getting an economic response to added fertilizer is high, and above which the probability of such a response is low.

The value of the "critical limit" for zinc (1.81 ppm) in soils used for lentil crops was highest with the dilute (hydrochloric—sulphuric) acid mixture. This was followed by DTPA-ammonium carbonate (1.51 ppm), dithizone (0.52 ppm), ammonium acetate, pH 4.6 (0.42 ppm) and magnesium chloride (0.34 ppm). Extractants which extracted more zinc gave higher values for the critical limit and vice versa.

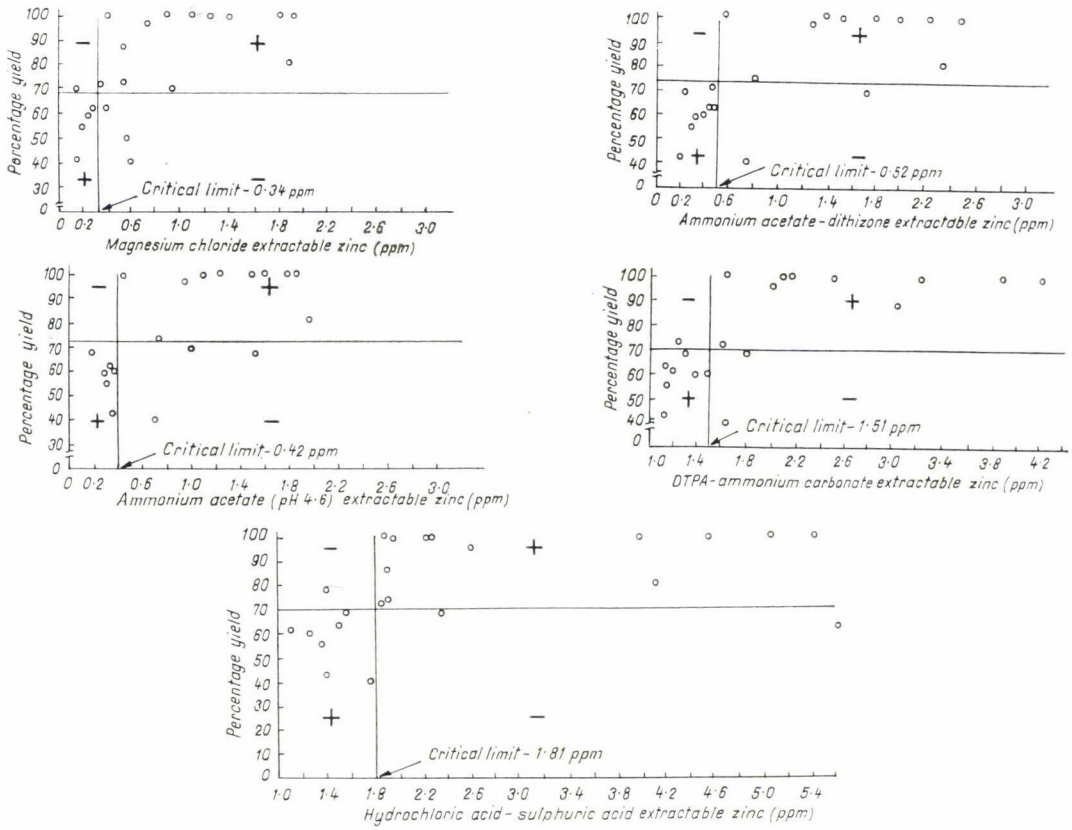

Fig. 1. Scatter diagram of percentage yield of lentil versus extractable zinc in soil

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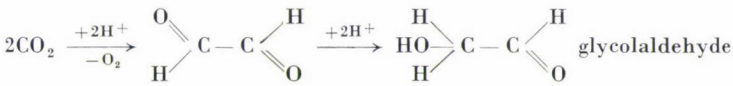
CONTRIBUTION

Contribution to the paper of Á. Nosticzius: Indirect examination of the role of formaldehyde and glycolaldehyde in carbon metabolism published in this periodical, **25** (1—2). 183—208. 1976.

DOES PHOTOSYNTHETIC GLYCOLALDEHYDE FORMATION OCCUR AT AN ENDOGENOUS LEVEL AND WHAT IS ITS INTENSITY?

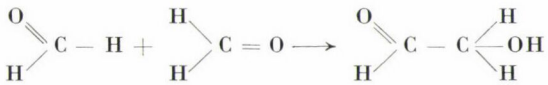
Nosticzius (1973, 1976) produces indirect evidence of the role of formaldehyde, glycolaldehyde and glyceric aldehyde in sugar synthesis related with the carbon cycle. By adding one- and two-carbon atom precursors under illuminated conditions he attained the same extent of stimulation on the saccharose, galactose and ribose levels as with glyceric aldehyde. Glycolaldehyde takes part directly in Calvin's carbon cycle mechanism (Calvin 1955), thus the main point of the question is whether photosynthetic glycolaldehyde formation occurs at an endogenous level, and if so, what is its intensity.

O'Neal *et al.* (1972) started from carbon dioxide and confirmed the idea of glycolaldehyde formation suggested by Baldry *et al.* (1966) with the incorporation of CO_2 labelled with radioactive carbon, since both carbon atoms of the glycolaldehyde showed nearly the same radioactivity. The photosynthetic formation of glycolaldehyde was proved by the following reductive steps:



It is obvious that during the multi-stage reduction two molecules of water will be formed, using four activized protons, and not molar oxygen.

The other photosynthetic pathway of glycolaldehyde formation, supposedly with an intramolecular transformation of formaldehyde, is suggested by Nosticzius (1973, 1975) on the basis of indirect experimental results. The transformation of the two molecules of formaldehyde into glycolaldehyde can be given by the following formula:



The glycolaldehyde formation of the first scheme is increased, with a simultaneous decrease in the intensity of photosynthetic carbon dioxide fixation as a response to mono-iodic acetic acid and arsenite, while the value of the photosynthetic quotient also changes, according to data published by Calo—Gibbs (1960) and Gibbs—Calo (1960).

As for the second scheme, all that is known from indirect evidence is that under illuminated conditions the amounts of glycose, galactose and ribose increase in almost the same measure as a response to the addition of formaldehyde, glycolaldehyde and glyceric aldehyde. Glycolaldehyde formation starting from formaldehyde under experimental conditions is strongly suggested by the fact that under the influence of glycolaldehyde and glyceric aldehyde almost the same quantities of glycose, galactose and ribose are formed in the definite propor-

tions of the photochemical systems P I and P II. However, as to the mechanism of photosynthetic sugar formation, it is not known whether glycolaldehyde formation from formaldehyde takes place at an endogenous level too, or whether this new pathway is only initiated under the influence of an extra dose of exogenous formaldehyde. The subject matter given in the paper makes the existence of the second scheme probable.

Further questions have arisen concerning the ratio of the first and second schemes both at an endogenous level of the components and under the influence of exogenous precursors, and also as a consequence of modifications in the biochemical mechanisms activated by special inhibitors. The question of whether the above two schemes regularly occur in higher green plants, and in algae and photosynthetic bacteria, should also be answered.

Further, it seems probable that in the processes of electron and proton transport induced by photochemical energy absorbed by the photochemical systems P I and P II, endogenous and exogenous cytokinines also take part (HORVÁTH—POZSÁR 1974), while the intensity of photosynthetic carbon dioxide fixation is in positive correlation primarily with the soluble protein level of the chloroplast, as described in our earlier publication (POZSÁR 1971).

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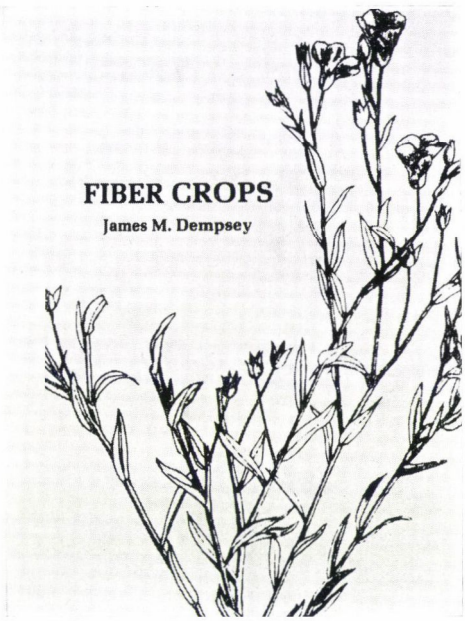
RECENSIONES



J. M. DEMPSEY: *Fiber Crops.*
The University Presses of Florida, 1975.

Professor Dempsey (1912—1972) approaches his subject with a deep professional knowledge, a wide range of practical experience and an obvious familiarity with the material. In his book "Fiber Crops" he deals with the nine most important textile fibers, primarily with those forming the raw materials of various branches of the textile industry.

The nine industrial fiber crops concerned are: 1) Flax, 2) Hemp, 3) Ramie, 4) Jute, 5) Kenaf, 6) Roselle, 7) Urena, 8) China jute and 9) Sunn Hemp.

Of the fiber crops dicussed those numbered 1—3 are classified in the book as fine textile fiber crops and 4—8 as sack industries fiber crops, while 9 is placed among the raw materials of rope and cordage making.

The author does not deal with the different hard fibers used in the textile industry, nor with leaf and fruit fibers.

Professor Dempsey's work reflects his life-long endeavour to know all about this subject. Besides his theoretical studies, research activities and publications, he carried out and directed practical agrotechnical work in almost all those places in the world where the plants discussed in the book are grown. The unity of theory and practice has made it possible, apart from the morphological, biological, botanical, economic, statistical and production data of the individual fiber crops, to give practical advice and guidance to growers. It is a well-known fact that in the United States of America the production of bast fibers and fiber crops is negligible, as cotton is dominant in every respect. The author made a successful attempt e.g. to establish a fully mechanized ramie plantation in Florida which he also managed for some time. His research and advisory work helped a number of countries in South-East Asia to achieve an efficient kenaf production.

This work, of nearly 500 pages with many tables, data and photos, is also of assistance in choosing the most suitable harvesting machines. The reader is made acquainted

with several kinds of equipment which may have escaped his attention so far (e.g. the ramie seed-drill, a Dutch hemp harvester, flax-pullers, etc.).

Flax. The chapter begins with the presentation of the economic importance of flax, followed by a brief summary of its 7000 year history. Then we are given useful practical information about the following questions of cultivation: adaptation, climatic requirements, demands on the soil, botanical problems, genetic aspects, breeding, rotation, cultural practices, methods, techniques and advice, harvest mechanization, rippling, drying, seed handling, pests of the stalk and fiber, soil preparation to ensure the next crop, various kinds of retting, turbine scutching, yields, characteristic features and classification of the flax fiber and flax-tow, detailed references and contents.

Hemp. As to structure this chapter is similar to the previous one, but contains in addition the following points: hemp as a narcotic, the cottonization of hemp, etc.

Among the references a number of Hungarian sources are found (Iván Bócsa).

The other textile fibers listed before are treated in the book in a similar way.

The statistical data in the tables, concerning the growing area, yield and amounts of fibers produced, are accurate, up-to-date, containing data up to and including the first years of the seventies, and also present the relevant figures for the Soviet Union and the socialist countries.

Such a thorough, comprehensive, exhaustive and high level work has not been published on this subject for decades. Works of a similar character were perhaps published in the mid-thirties by the J. Springer Verlag, and some Soviet manuals may be ranked with these works. It should be of considerable help to those interested in the subject in Hungary.

T. Beck

Le contrôle de l'alimentation des plantes cultivées. 3e Colloque européen et méditerranéen Budapest, (3rd European and Mediterranean Conference on the nutrition control of cultivated plants). Akadémiai Kiadó, Budapest, Vols. I, II, 1010 pages.

In this book we find a list of names which shows that 102 foreign participants from 14 countries and 57 Hungarians took an active part in the work of the conference. A total of 103 lectures were delivered, the material of which is contained in two volumes. The subject matter of the conference is treated on 1010 pages divided into six sections.

Section I contains lectures dealing with the general principles of the leaf diagnosis method and analytic-methodological questions concerned with its application (23 lectures). In Section II lectures discussing the mineral nutrition of cereals, fodder and industrial plants are found (13 lectures). Section III contains the subject matter of lectures delivered on the mineral nutrition of vegetables, ornamentals and arborescent

plants (10 lectures). In Section IV the mineral nutrition of Mediterranean and subtropical plants is discussed (14 lectures). Section V deals with the mineral nutrition problems of grape varieties (24 lectures). In Section VI lectures held on the mineral nutrition of various fruits are found (19 lectures).

The lectures are published in French, Russian, English and German, and with a few exceptions each of them is completed with a summary written in English. It is a pity that English and Russian summaries are not added to all the lectures.

We should like to give below more detailed information about the subjects discussed in the six sections. The fullest particulars will be given for Section I, because it is here that many fundamental questions are dealt with which may be of general interest.

Section I includes a lecture on the leaf analysis of cereals as a method of determining the necessary amount of fertilizer. The marginal values of toxicity were established by boron and iron analyses of tomato leaves. A separate lecture was delivered on the accuracy and sensitivity of the analytical methods used in leaf diagnosis. The authors determined the necessary degree of accuracy in the case of various concentrations of macro- and micro-elements in the leaf.

In one of the lectures ionic nutrient transport in plants and conditions influencing the ion balance are discussed. Namely, acidity and alkalinity are compensated in the plants by cation and anion uptake, respectively. In the course of the nitrogen and sulphur cycles the chemical reaction in the plants generally shifts. The proper application of leaf diagnosis requires a knowledge of these processes.

Investigations were made into the possibilities of employing a mathematical model for the application of leaf diagnosis data to an advisory service in fertilization. Through studies on the mineral nutrition of plants, by means of soil and plant analyses, it is possible to determine the optimum amounts of nutrients required to obtain the largest possible yields. Investigations into the relation between fertilizer efficiency and light intensity have revealed that in plants (e.g. tobacco) kept in the shade the mineral and organic matter content of the leaves changes.

According to the results of the investigations this plant analysis could become the basis of fertilization and serve not only to check whether the level of fertilization was appropriate, but also to find out what kind of nutrient deficiency occurred during the vegetative period and elaborate a rational system of fertilization.

In soil exploitation trials carried out with grasses grown in plastic culture pots the fertility and nutrient level of the soil and the economic efficiency of nutrient utilization could be determined. In the case of fruit trees the mineral nutrition data of plants, determined by leaf diagnosis, were processed by computer for the purpose of advisory work in fertilization.

Besides the general problems Section I also includes descriptions of investigations into the correlation between the phosphorus and boron uptake of plants, and between the magnesium level of the soil and magnesium uptake by plants. The fertilizing effect of peat and composts was studied at different degrees of fermentation. Further lectures dealt with methodological problems. The suitability of an atomic absorption method for determining calcium, magnesium, manganese, zinc and copper contents in plants was tested.

Etalons (standard samples) required for the calibration of the leaf analyses were discussed in a separate lecture. The effect of dust rising from the ground and settling on the surface of the plant must not be left out of consideration either, because if an improper method of preparation is employed it will influence the results.

One lecture dealt with the errors (losses) occurring when plant materials are reduced to dry ashes. Soviet authors gave an account of the results obtained by the application of leaf diagnostics in the Soviet Union. Section I includes, further, the description of a rapid acid hydrolysis method elaborated for the purposes of leaf analysis. In Section I are 7 Russian, 5 Hungarian, 4 French, 4 Spanish

lectures and 1 Czechoslovakian, 1 Belgian and 1 Dutch.

Section II contains lectures held on the mineral (macro- and micro-element) nutrition of wheat, maize, potato and sugar-beet as studied by leaf analysis. The authors followed the action of mineral nutrition on the quantity and quality of yield.

The lectures contained in this section gave an account of the application of leaf diagnosis methods for solving concrete problems of fertilization. The successful use of the method is demonstrated by a large number of tables and diagrams. Section II includes 7 Russian, 3 Spanish, 2 Hungarian lectures and 1 French.

Among the lectures in Section III there is one on the leaf diagnosis of mineral (NPK) nutrition in arborescent plants. A separate lecture gives an account of growth studies on tulips by means of the ^{14}C isotope. One of the lectures in this section presents the results of investigations into the mineral nutrient supply of rose plants with the aid of leaf diagnosis. The questions of the mineral nutrition and fertilization of paprika plants were discussed in two lectures. Analyses of the chemical composition and mineral cycles in tomato plants were reported on in three lectures. Investigations were made into the chemical composition of carrots, an account of which is given in this section. Section III contains 3 Russian, 2 Hungarian lectures, further 1 Polish, 1 Czechoslovakian, 1 Rumanian and 1 Danish.

In Section IV lectures dealing with the mineral nutrition of subtropical plants are found. We are informed about the fertilization problems of the tea plant, as well as about the occurrence and alleviation of magnesium and manganese deficiencies. Results of investigations into the zinc and calcium nutrition of citrus plants are presented. A separate lecture gives an account of analyses concerning the nitrogen, potassium and calcium nutrition of the eucalyptus. Investigations were made into the nitrogen, phosphorus and boron nutrition of olive trees. Several lectures discuss the mineral nutrition and fertilization problems of orange trees. Section IV contains lectures delivered by 5 Spanish, 4 Moroccan, 3 Russian authors and 1 Israeli and 1 French author.

Lectures in Section V give an account of mineral nutrition in different grape varieties as studied by leaf diagnosis. The lectures included in this section dealt exclusively with the results of investigations made on grapes.

A number of lectures discussed the use of leaf diagnosis in solving fertilization problems, and the results of studies on the correlation between the quality of the wine and the mineral nutrition of the grapes. A separate lecture gave an account of the effects of soil cultivation, irrigation and fertilization on the nitrogen, phosphorus and potassium contents of vine leaves. The lectures contained in this section were held by 3 French authors, 1 Russian, 1 Yugoslav, 1 Hungarian, 1 Bulgarian and 1 West German author.

In the lectures of Section VI the authors presented the results of investigations into the mineral nutrition of peach, apricot, apple, pear, strawberry and raspberry. The lectures discussed the possibilities of using the results of leaf diagnosis for advisory work in fertilization. In the case of apple trees the possibility of drawing conclusions from the results of leaf analysis on the properties of quality was also studied. The lectures were held by 6 Hungarian, 4 Russian, 4 Spanish, 2 Yugoslav, 2 French participants and 1 Danish.

The material of the two volumes clearly shows the possibilities of an international scientific division of labour and proves the usefulness and efficiency of an exchange of information which enables results obtained by the application of the same method (leaf diagnosis) to be compared. The subject matter of the conference renders it possible to compare different plant varieties, or identical varieties under different environmental conditions for mineral nutrition, and thus determine the correct course of further investigations. In possession of a wide range of information it will be easier to establish the optimum conditions of fertilizer utilization.

The book is of excellent quality both technically and in format.

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RECENSIONES

Günter M. Hoffman
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Fritz Schönbeck
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Hubert Wilbert

Lehrbuch der Phytomedizin

Von Prof. Dr. Günter M. Hoffmann, Leiter des Instituts für Bodenkunde, Pflanzenernährung und Phytopathologie der Technischen Universität München in Weihenstephan; Prof. Dr. Franz Nienhaus, Leiter der Abteilung Virologie am Institut für Pflanzenkrankheiten der Universität Bonn; Prof. Dr. Fritz Schönbeck, Direktor des Instituts für Pflanzenkrankheiten und Pflanzenschutz der Technischen Universität Hannover; Prof. Dr. Heinrich C. Weltzien, Direktor des Instituts für Pflanzenkrankheiten der Universität Bonn; Prof. Dr. Hubert Wilbert, Leiter der Abteilung Entomologie am Institut für Pflanzenpathologie und Pflanzenschutz der Universität Göttingen.

1976. 490 Seiten, mit 101 Abbildungen, 62 Übersichten und 13 Tabellen. Balacron brosch. DM 88,–

Mensch, Tier und Pflanze sind als Lebewesen eigentümlichen Veränderungen und Abweichungen im Ablauf physiologischer Prozesse unterworfen, die als Krankheiten bezeichnet werden. Die Medizin als wissenschaftliche Arbeit an der Krankheit, an ihrer Diagnose und Therapie, kennt daher drei Disziplinen: die Humanmedizin, die Veterinärmedizin und neuerdings auch die Phytomedizin, deren Aufgabenbereich weit über den der traditionellen Pflanzenpathologie hinausgeht.

So hat sich der Begriff »Phytomedizin« im deutschen Sprachraum nunmehr durchgesetzt und wurde daher von den Autoren für den Titel dieses modernen Lehrbuches gewählt, das aus ihrer täglichen Praxis als Hochschullehrer heraus entstanden und in seiner didaktischen Konzeption auf die Ausbildung des akademischen Nachwuchses ausgerichtet ist. Das Werk vermittelt zugleich die Grundlagen für ein eigenes und aktuelles Berufsbild des Phytomediziners, das den heutigen wissenschaftlichen und praktischen Anforderungen beim Schutz der Pflanzenproduktion, beim Gesundheitsschutz für Produzenten und Verbraucher und den vielfältigen Aufgaben beim Umweltschutz voll entspricht.

Entgegen der herkömmlichen Gliederung des Stoffes nach Wirtspflanzen und Schadursachen wird hier von einer breiten Allgemeindarstellung der Infektions- und Befallsabläufe sowie der Reaktion der Wirtspflanzen und einer Beschreibung der Krankheitserscheinungen ausgegangen, gefolgt von einer Einführung in die Populationsdynamik und Epidemiologie. Das letzte Kapitel ist den praktischen Maßnahmen des Pflanzenschutzes in hygienischer und therapeutischer Sicht gewidmet. Von der Pflanzenquarantäne bis zu den verschiedenen chemischen, physikalischen, biologischen, biochemischen und biotechnischen Verfahren und ihren Anwendungsbereichen werden alle Möglichkeiten und Wirkungsweisen dargestellt. Das reichhaltige Werk wird damit ergänzt zu einem enzyklopädischen Lehrbuch des Pflanzenschutzes für alle, die sich in weitestem Sinne in Forschung und Lehre, in Studium und Praxis mit phytomedizinischen Fragen und Problemen beschäftigen.

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РЕЗЮМЕ

МЕТОДИЧЕСКОЕ ИССЛЕДОВАНИЕ И РЕЗУЛЬТАТЫ ПРОГНОЗА УРОЖАЯ ЗЕРНОВЫХ КУЛЬТУР

ДЬ. САЛАИ

В интересах разработки метода прогноза урожая зерновых культур нами обработаны данные по компонентам урожая многочисленных колосьев. Между отдельными признаками и урожаем зерна были определены взаимоотношения. На основании данного метода выяснено, что для достоверного прогноза урожая недостаточны употреблявшиеся до сих пор компоненты урожая. Необходимо было создать новые параметры для разработки метода прогноза урожая. Поэтому в наших исследованиях стали использовать так называемую «общую длину колосьев», которая представляет собой произведение количества колосьев на м² и средней длины колосьев. В то же время нами определён вес зёрен на 1 см колоса, который получил название «удельный вес зерна колоса». Путём применения этих параметров, мы получили более достоверные результаты расчетов для прогноза урожая, которые уточнились ещё коррекцией, зависимой от количества колосьев на 1 м² и от общей длины колосьев. Наконец, для практических целей, нами составлена таблица прогноза урожая.

ИНДУЦИРОВАННЫЕ МУТАЦИИ В РАННИЕ СТАДИИ ОНТОГЕНЕЗА У NIGELLA DAMASCENA L.

ФАН ФАЙ, В. Ш. АНДРЕЕВ, Э. Ф. МЕЛЬКОНОВА

Наш метод обработки гамет, зигот и проэмбрий с помощью химических и физических мутагенов по всем показателям превосходил обработку сухих семян. Обработка, примененная в ранней стадии онтогенеза, по сравнению с обработкой сухих семян, не только вызвала большую мутационную рату, но и расширила спектр мутаций. Было получено 55 типов наследственных изменений, которые затрагивали структуру вегетативных и генеративных органов. Особенный интерес представляет собой мутационное изменение генеративных органов. Оптимальные дозы для данного объекта и метода обработки, которые вызывали высокую мутационную рату, (до 96% семей с изменениями), следующие: ЭИ — 0,003% (16 часов), НМК — 0,005% и 0,008% (16 часов). Метод обработки сухих семян сказался намного менее эффективным и занял второе место по всем показателям по сравнению с обработкой гамет, зигот и проэмбрий.

СОДЕРЖАНИЕ ПИТАТЕЛЬНЫХ ВЕЩЕСТВ ОСАДКОВ, ПРОХОДЯЩИХ ЧЕРЕЗ РАСТИТЕЛЬНЫЙ ПОКРОВ В ЭКОСИСТЕМЕ ДУБОВОГО ЛЕСА (QUERCETUM PETRAEAE-CERRIS)

М. САБО

Нами исследовалось количество K, Ca, Na, Mg, Mn, Fe, S, N, Cl и P в атмосферных осадках, далее в воде, проникшей через листву и стекшей вниз по стволам, в одной климазональной лесной экосистеме в Венгрии в течение одного года. Приведено количество минеральных веществ, по элементам, помесячно и суммарно за целый год, попадающих с водой из атмосферы на 1 га лесной почвы. Также определёны связи степенной функции между количеством воды, проникающей через листву и атмосферных осадков, и концентрацией в них элементов.

БИОПОЛИМЕРНЫЕ-МЕТАЛЛСОДЕРЖАЩИЕ КОМПЛЕКСНЫЕ СИСТЕМЫ. I. ЭКСПЕРИМЕНТЫ ПО ПРИГОТОВЛЕНИЮ ТОРФЯНОГО ГУМУСА ВЫСОКОЙ ЧИСТОТЫ И ИХ МЕТАЛЛСОДЕРЖАЩИХ СОЕДИНЕНИЙ

Б. ЛАКАТОШ, Й. МЕИСЕЛЬ, Г. МАДИ

Были приготовлены, лишённые металла, чистые коричневые торфяно-гумидные кислоты путем экстрагирования разбавленным раствором гидрат-окиси-натрия или прифосфат-натрия, далее, с комбинированным применением ЭДТА и анион- и катион-заменяющих смол при комнатной температуре. Удаление протеинов, полисахаридов и соединений типа фенол-карбоксильной кислоты производилось путем кипячения с концентрированной серной кислотой. Получение системы ферментативного гумуса низкого молекулярного веса и гимато-мелановой кислоты осуществлялось микробиологическим путем. Фульвоновая кислота, полученная модифицированным методом Chalupa—Rochus, была освобождена от металлических ионов осаждением в виде медных фульватов, и последующей обработкой сульфидом аммония. Металлсодержащие гуматы и фульваты высокой чистоты были получены путем реакции между чисто-гумидными веществами и смолами типа карбоксильной кислоты, насыщенными металлическими ионами. Приготовление гумидных субстратов высокой чистоты и металлсодержащих гуматов позволяет определить физические и химические свойства фракций и также облегчает физиологические эксперименты.

Acta Agronomica Academiae Scientiarum Hungaricae, Tomus 26 (3—4), pp. 217—229 (1977)

METHODOLOGY AND RESULTS OF YIELD PREDICTIONS FOR CEREALS

By

Gy. SZALAI

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In order to find a proper method of yield prediction in cereals we have processed long series of data on the yield components of cereals, and studied the relation of the different properties to grain yield. On this basis the components of yield so far used were found to be insufficient for a reliable yield estimation. We therefore established new parameters to be used in elaborating the method of yield prediction. Accordingly, the number of spikes per m^2 multiplied by the average length of spike was employed as "total spike length" in our investigation. At the same time we determined the weight of grain per 1 cm of spike and called it "specific grain weight of spike". By using these parameters we obtained calculation results sufficient to predict the yield with, and made them even more accurate with a correction dependent on the number of spikes per m^2 and the average length of spike. Finally we constructed yield estimation tables for the use of farmers.

Introduction

In 1968 our Institute was requested to elaborate a reliable yield estimation method based on exact analyses for the most important agricultural crops. Within this programme a method of predicting winter wheat and winter barley yields several weeks before maturing with a maximum of 5—6% error had to be evolved.

The traditional method of crop estimation is based on the detailed evaluation of yield components (PODÁNY—SZEKERES 1968, MIRZINSZKI—PAVLICI 1964). By establishing the numbers of spikes and spikelets per unit area the authors obtained the number of grains, but even so the deviations from the actual yield were large (3—6 q/ha).

BÁLINT (1967) and BERGER (1970) also determined the numbers of spikes and grains per unit area, while others (SVETKA—KORIC 1965, KOVÁTS—SVÁB 1966, SAULESCU et al. 1963) completed the examinations by pointing out correlations between yield components and yield, analysing at the same time the interactions of the different factors. The results — though not always unambiguous — show that the yield components are generally in negative correlation with one another — e.g. number of spikes per unit area and grain yield per spike, as well as number of spikes per unit area and thousand-grain-weight.

SVÁB (1967) calls attention to the importance of keeping to a biologically determined chronological order. Namely, the change of a yield component influences one or more other yield components. On the basis of physiological studies attention is also called to this, quite rightly, by KÜCHLER (1972).

HANUS (1969) elaborated a crop estimation procedure based on meteorological data for cereals which has given favourable results. Here we must take into consideration the fact that he carried out his work in a balanced oceanic climatic zone. According to RICOUR (1968) and some other authors (JEH 1965, WILLIAMS—ROBERTSON 1965, BAIER—ROBERTSON 1967) yield estimations based exclusively on meteorological data cannot be reliable. It is to this that attention is called by DENISOV (1970) too, who points out that in the western region of the Soviet Union the winter cereals undergo great changes during vegetation.

The Soviet research worker ULANOVA (1965 and 1966) takes into account the precipitation conditions when concluding on the prospective yield from the number of spring shoots and the moisture content of the soil.

In our work we started from the relationship between yield components and yield. It is on this work and the results attained that we wish to give a brief report in this paper.

Material and Method

The classic formula for the yield prediction of a growing crop is

$$x = \frac{a \cdot b \cdot c \cdot d}{1000}$$

where x is the g/m² yield, a the number of spikes per m², b the number of spikelets per spike, c the number of grains per spikelet, and d is the thousand-grain-weight.

The complete processing of large numbers of spikes is a highly time-consuming operation which causes difficulties in the producing farms. Besides, the possibility of error is high, because 1—2 grains missed per spike result in a 3—6% difference. A still more important factor of unreliability is the possible deviation of thousand-grain-weight from the average. A 1 g difference increases the error by 2.5%. Furthermore, we had to provide for the relatively easy adaptation of the prospective method.

As a first step, we determined the extent of differences resulting from the change in thousand-grain-weight. The available data showed that the change in thousand-grain-weight alone may have caused a 10 to 20% error of prediction (Table 1). We thus drew the conclusion that even the precise determination of grain number per unit area would not necessarily lead to reliable results.

In later studies we determined the plant parts and yield components which might possibly be related to the grain yield. All important winter wheat and winter barley varieties grown in Hungary were included in the examination: the winter wheat varieties Bezostaya 1, Fertődi 293, Mironovskaya 808 and Libellula, and the winter barley varieties Lédeci Béta and Horpácsi kétsoros. For the examinations 50 0.25 m² samples of each variety were collected from three different production regions of Hungary. Thus the calculations for any region contain in a single year data on several thousand spikes. In this paper the examination results for four years (1969—1972) are presented.

The sampling area was marked out with a circular border, or according to rows. Marking out was carried out mechanically at random. Samples were collected in the days following full ripeness and the spike zone was reaped. By this plant parts (spikes and the upper parts of the stalks) up to 25—35 cm below the average level of the spike tips are under-

Table 1

Trend of thousand-grain-weight (g) in three winter wheat varieties at the Kompolt Station of the National Agricultural Variety Testing Institute

Year	Wheat varieties		
	Bezostaya 1	Fertődi 293	Mironovskaya 808
1963	38.5	38.5	44.6
1964	36.5	32.4	31.0
1965	41.8	36.6	41.4
1966	46.8	42.4	49.0
1967	45.6	46.4	47.8
1968	38.1	38.0	37.6
6-year average	41.2	39.0	41.9

stood. The second growth grain yield — according to our measurements — amounts to 80 kg/ha in winter wheat and 120 kg/ha in winter barley. This amount is more or less equal to losses occurring during transportation and storage and can thus be left out of consideration, being not more than 2—3% of the total volume. The harvesting of the spike zone is relatively easy. The material of a row 1 running metre in length can be grasped and cut off in four or five fistfuls. The following measurements were made on the samples harvested:

weight of total material on the model area in g, weight of unthreshed spikes on the model area in g, number of spikes, average length of spikes in cm, weight of grain yield from threshed samples in g, thousand-grain-weight in g, and height of plants in cm (only in two years).

The following values were calculated from these data:

grain yield per spike in g, number of grains per spike, grain number per 1 m of spike, grain yield per 1 m of spike in g, that is, the specific grain weight of the spike, total length of spike (number of spikes x average length of spike), grain yield as a percentage of the total weight of the sample, and grain yield as a percentage of the unthreshed spikes.

The data were arranged in tables (Tables 2 and 3). In addition to a statistical comparison the two-variable linear regression equation was used to determine the closeness of the correlations and the extent of modification of the dependent variable. At the same time we calculated the determination coefficient to show the percentage influence of the given factor on the yield.

The regression formula is:

$$y = a + bx,$$

where x is the independent variable (in the present case the measured or calculated data) and y is the dependent variable (here the grain yield of the model area).

Further, we studied the interactions of yield components in detail. We carried out 23 correlation analyses for each lot, and controlled the reliability of the results by discriminatory calculations. The data of four years were processed by computers.

Results

The total weight of the sample (spike with 20—30 cm of straw) and the weight of unthreshed, ripe spikes showed a very close correlation with the amount of yield and thus seemed to be utilizable. The problem, on the other

hand, was that any estimation method based on the weight of the spike could only be employed after the maturation of cereals.

Plant height and grain yield — within the same variety — were found to be in loose correlation (0.2—0.3) in the first two years, therefore these data were no longer recorded. In our opinion this parameter cannot be used in yield prediction.

The spike number showed medium or close correlation with the grain yield and could thus be taken into account when predicting the yield. The average value of the correlation coefficient is 0.8, that is, it determines the amount of yield with 64% reliability. This value did not satisfy us, so we tried to obtain more reliable data.

The yield per spike for samples collected from different plots showed considerable differences, depending first of all upon the length of the spike. The same was found when individual spikes were compared. Therefore, we had to find a parameter which equalized the different size spikes. With this in view we multiplied the number of spikes by their average length and obtained the amount of the generative part (spike) of the plant expressed in a unit of linear measure. This parameter was given the name "total spike length".

The total spike length was in very close correlation with the grain yield; the value of r reached, or even exceeded, 0.9, so we considered this parameter to be utilizable in yield prediction. The correlation was linear, as shown by Figs 1 and 2. On the basis of four years' data the following regression values were obtained:

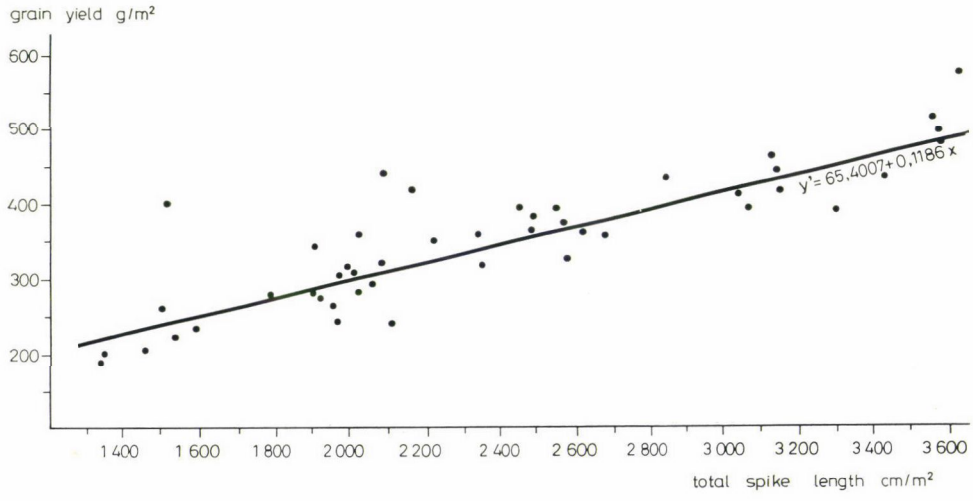

Fig. 1. Correlation between total spike length and grain yield in Bezostaya 1 winter wheat, by actual calculation and by regression analysis (Kompolt, 1972, n = 50)

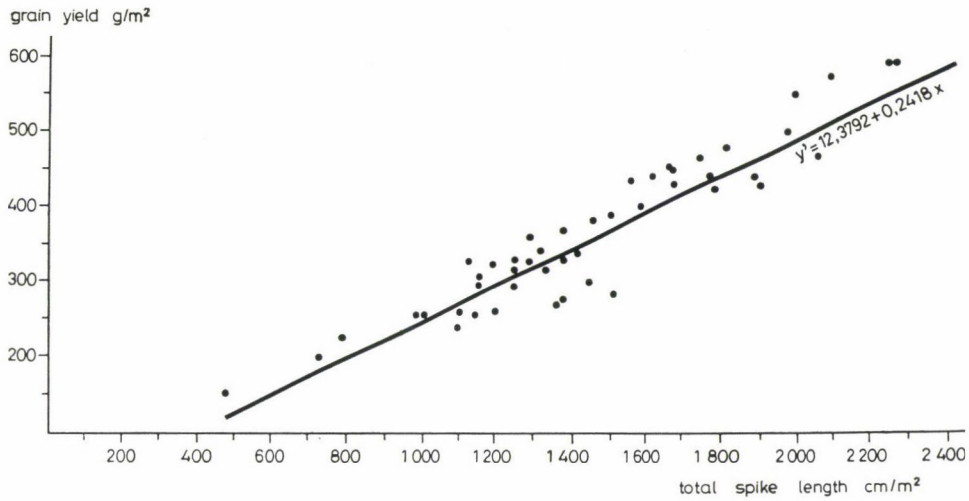

Fig. 2. Correlation between total spike length and grain yield in Lédeci Béta winter barley, by actual calculation and by regression analysis (Kompolt, 1972, n = 50)

Table 2

Yield components of the winter wheat variety Bezostaya 1 as a plot average (50 sampling areas) in 1969

Designation	Unit	Site of experiment		
		Kápolna	Kápolna	Nagyút
Spike	number/m²	317	310	148
Grain yield per spike	g	1.21	1.05	1.32
	number	28.60	25.63	32.10
Thousand-grain-weight	g	42.47	41.16	41.05
Grain yield per m²	g	385	327	195
	number	9065	7945	4750
Average spike length	cm	6.73	6.78	6.88
Total spike length	m/m²	21.33	21.01	10.18
Number of grains per 1 m of spike	number	425	378	466
Grain weight per 1 m of spike	g	18.05	15.56	19.15
Percentage grain weight to spike weight	%	74.68	76.93	76.73
Percentage grain weight to the total weight of the sample	%	67.34	64.90	64.47

Table 3

Yield components of the winter barley veriety Lédeci Béta as a plot average (59 sampling areas) in 1969

Designation	Unit	Site of experiment			
		Nagyút	Nagyút	Nagyút	Kápolna
Spike	number/m²	157	199	171	175
Grain yield per spike	g	1.69	1.62	1.62	0.21
	number	34.72	34.73	34.46	27.67
Thousand-grain-weight	g	48.80	46.59	47.12	43.65
Grain yield per m²	g	266	322	276	223
	number	5461	6911	5857	5109
Average spike length	cm	5.94	5.63	5.82	5.13
Total spike length	m/m²	9.33	11.20	9.96	8.98
Grain number per 1 m of spike	number	584	617	586	563
Grain weight per 1 m of spike	g	28.51	28.75	27.63	24.60
Percentage grain weight to spike weight	%	83.07	83.88	82.72	82.37
Percentage grain weight to total weight of the sample	%	73.71	74.89	74.34	73.74

for winter wheat Bezostaya 1

$$a = 74.75$$
$$b = 0.119$$
$$r = 0.86$$

By substituting the a and b values in the regression formula we obtain the prospective yield. For example on an area where the number of spikes is 400/m², average length of spikes 7 cm and the total spike length 2800 cm the following result will be obtained:

$$y = 74.75 + 0.119 \times 2800 = 407.96 \text{ g/m}^2 = 40.8 \text{ q/ha}$$

For winter barley the rules are more or less the same as for winter wheat. The r value of total spike length and grain yield was 0.79—0.92 within a year, and 0.84 on the average of several years.

In order to control the reliability of total spike length we calculated the confidence limits, which gave a satisfactory result. In the range where most of the cases are found this method of estimation resulted in a possible error

of 90—120 kg/ha. The same result was obtained when analysing data both of a single year and of several years. As an example we present here the data obtained for Bezostaya 1 in the Kompolt district in 1972 and on the average of four years (Tables 4 and 5; Figs 3 and 4. The unit for the confidence limits is g/m^2). The results obtained for winter barley are similar, and the confidence limits are even lower. The confidence value of the prospective yield was also calculated for both types of plant on the basis of the number of spikes; in this case the number of spikes per unit area was regarded as an independent variable. The value obtained for the confidence limits with this method for a single year was 30—100% higher than when using the total spike length in the calculation.

Table 4

Confidence values for correlation between total spike length and grain yield in the winter wheat variety Bezostaya 1 (Kompolt, 1972, n = 50)

$X_i - X$	Y_i	hy_i	Confidence limits	
			upper	lower
1348.80—2570.82 = —1222.02	225.32	±18.99	244.31	206.33
1959.81—2570.82 = — 611.01	297.83	±12.44	310.27	285.39
2570.82—2570.82 = — 0.00	370.30	±10.15	380.45	360.15
3172.71—2570.82 = + 601.89	411.68	±12.44	454.12	429.24
2774.60—2570.82 = +1203.78	513.07	±17.59	530.66	495.48
4376.49—2570.82 = +1805.67	584.45	±24.88	609.33	559.57
4978.40—2570.82 = +2407.58	655.84	±32.12	687.96	623.72

Table 5

Confidence values for correlation between total spike length and grain yield in Bezostaya 1 winter wheat (National data 1969—1972, n = 650)

$X_i - X$	Y_i	hy_i	Confidence limits	
			upper	lower
420.00—2461.97 = —2041.97	124.73	±17.29	142.02	107.44
1348.33—2461.97 = —1113.64	235.20	±12.29	247.49	222.91
2276.66—2461.97 = — 185.31	345.67	± 9.49	355.16	336.18
2461.97—2461.97 = 0.00	367.72	± 9.41	377.13	358.31
3390.30—2461.97 = + 928.33	478.20	±11.49	489.69	466.71
4318.63—2461.97 = +1856.66	588.67	±16.19	604.86	572.48
5990.00—2461.97 = +3528.03	787.56	±26.77	814.33	759.79

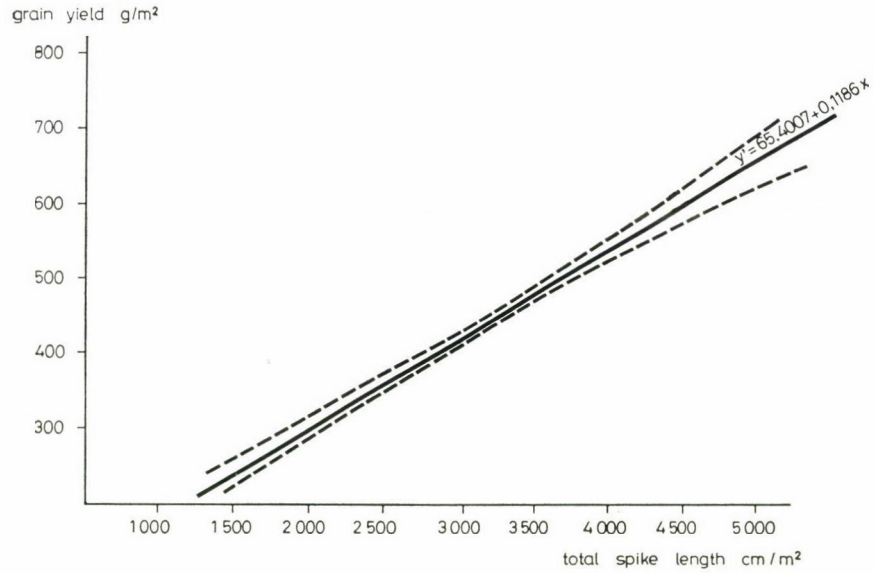

Fig. 3. Confidence limits for correlation between total spike length and grain yield in Bezostaya 1 winter wheat (Kompolt, 1972, n = 50)

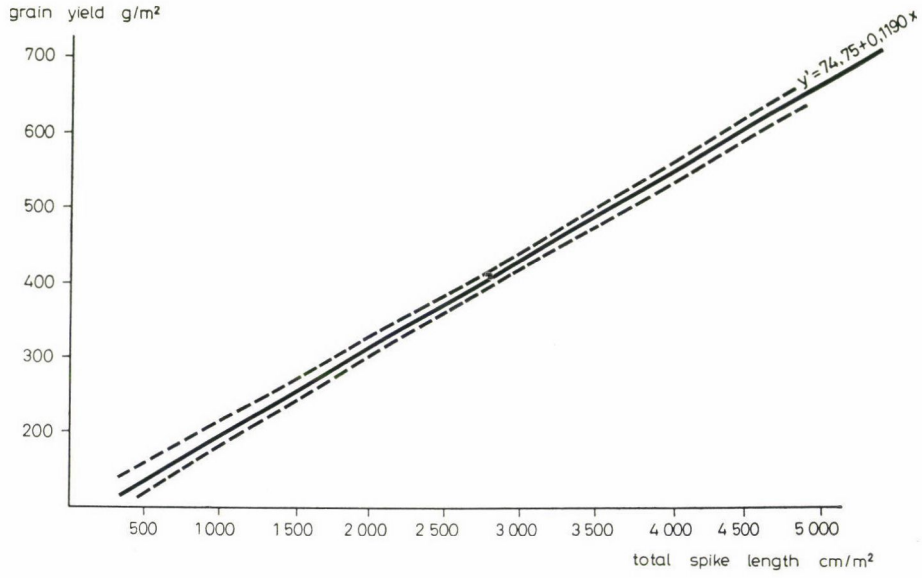

Fig. 4. Confidence limits for correlation between total spike length and grain yield in Bezostaya 1 winter wheat (National data 1969—1972, n = 650)

Table 6

Grain weights dependent on spike length for Bezostaya 1 winter wheat in 1968

Spike length, cm	Spike number	Grain yield per spike, g	Grain weight per 1 cm, g
3.1—4	2	0.74	0.18
4.1—5	19	0.52	0.10
5.1—6	179	0.69	0.11
6.1—7	430	0.89	0.13
7.1—8	323	1.10	0.14
8.1—9	46	1.30	0.14
9.1—10	1	1.78	0.18

Discrimination and path analyses — carried out by János Sváb, a biometry specialist — also demonstrated unambiguously that total spike length is the parameter that shows the closest correlation with the yield, undergoes the same changes, and gives reliable results when applied in yield prediction. In our work, however, with the same value of total spike length we found the yield of spikes of different length to show a deviation of several %. A larger yield is produced, for example, by 375 spikes each 8 cm in length than by 500 spikes 6 cm long, although the total spike length is the same (30 m) in both cases. Therefore in order to reduce the possibility of error we analysed in detail the modification of the total spike length. To that end we calculated the yield for 1 cm of spike (this must not be confused with the compactness of the spike which shows the closeness of the spikelets), which was larger in the first case than in the second (within a variety). There were distinct differences between the varieties (Bezostaya 1 : 0.15 g/cm, Fertődi 293 : 0.13 g/cm, Lédeci Béta winter barley: 0.27 g/cm). This parameter was given the name "specific grain weight of the spike" and changes occurring in it were studied in detail (Table 6). According to the results of our examinations this parameter changes not only with the length of the spike but also with the number of spikes per unit area. The change shows a positive direction in the first, and a negative direction in the second case. We must emphasize that these changes were small and could only be demonstrated by improving the reliability.

Our small plot experiments confirmed the stability of the specific grain weight, which is favourable from the point of view of yield prediction but also shows the regularity of the changes. To study the changes in yield components under different ecological conditions we set up a trial with three varieties of winter wheat and winter barley. Sowing was carried out 20 days earlier and

Table 7

Changes in the specific grain weight of Bezostaya 1 winter wheat spikes with respect to crop year — sowing time — grain yield

Sowing time	Amount of grain	1970	1971	1972	Difference from 1970		Average g/cm	Difference from II/2	
		grain yield g/cm			1971	1972		g/cm	%
I.	1	0.007	0.132	0.165	+0.125	+0.158	0.101	−0.048	−32
	2	0.070	0.132	0.160	+0.062	+0.090	0.121	−0.028	−19
	3	0.105	0.127	0.150	+0.040	+0.063	0.127	−0.028	−19
II.	1	0.150	0.150	0.162	+0.000	+0.012	0.154	+0.005	+3
	2	0.152	0.147	0.150	−0.005	−0.002	0.149	+0.000	0
	3	0.145	0.137	0.142	−0.008	−0.003	0.141	−0.008	−5
III.	1	0.125	0.175	0.135	+0.050	+0.010	0.145	−0.004	−3
	2	0.147	0.165	0.132	+0.018	−0.015	0.148	−0.001	−1
	3	0.150	0.150	0.135	+0.000	−0.015	0.145	−0.004	−3
SD±10%		0.037					0.037		

later than the optimum time of sowing, and 33% more and less germs were used compared to the optimum number of germs. The specific grain weight of the spike proved to be practically unchanged, only the early sowing — which is not used in practice — resulted in some difference. The specific grain weights of Bezostaya 1 are given in Table 7. Compared to the optimum germ number and sowing time, in the other treatments (with the exception of the plot sown at the same time with a reduced number of germs) the specific grain weight was only a few per cent lower on a three-year average. All this confirms the correctness of the processing results for samples obtained from the producing farms.

We studied the relationship between the number of grains per unit length of spike and the thousand-grain-weight. By excluding all other factors we obtained an unambiguously negative medium-close or close correlation. This is natural because the larger the number of fertilized flowers in a spike of given length, the smaller the amount of nutrient available for the development of one grain. Thus the two criteria compensate one another to some extent. Under favourable conditions of pollination the value of the thousand-grain-weight will be lower, while in the opposite case it will be higher. This can be accepted as a regular tendency, which shows that the weight of grains per 1 cm of spike is a more constant value than the number of grains for the same unit. Even the value of the thousand-grain-weight shows a lower fluctuation than this property.

Discussion

The elaboration of a yield estimation method was not a by-product of other examinations, as is the case in the work of most authors listed in the introduction of this paper, but was the main objective of our work. Taking this into consideration it is easy to understand that the methodology is rather new and neglects any other objective. That is why we left the spikelets, for example, completely out of consideration. This factor would increase both the labour intensity of the yield estimation work and the possibility of error. This standpoint — while biologically unacceptable — is justified by the objective of our work.

Dividing the spike into 1 cm section and multiplying the number of spikes per unit area by their average length may be considered as arbitrary, but in the present case it has served our purpose well. To apply the specific grain weight of the spike and discover how it tended to change was of crucial importance if any progress was to be made.

Calculations made for each district every year involved several repetitions and thus acted as a good control. The values obtained agreed in practice both with each other and with the results of a series of data running over several years (550—650 sampling areas of 0.25 m^2 each) and can thus be accepted as reliable.

We cannot, however, regard our results as anything final. The highly changeable weather conditions in Hungary may cause surprises, and in certain years the thousand-grain-weight may sharply decrease. This could make the method less reliable. Therefore we must continue to study the correlations between meteorological factors and thousand-grain-weight, and to disclose the phenomena occasionally causing a sharp decrease in thousand-grain-weight. In this way we shall be able to improve the reliability of our results by completing them with the results of examinations into meteorological factors.

As seen in the discussion of the results the height of the plant did not seem utilizable in predicting the yield. The low values obtained by us for the correlation between yield and plant height contradict the results of other authors. According to investigations by BALLA (1968) higher plants are more productive. We must note, however, that Balla's experiments were made with crossing progenies, while we worked with material collected in farms, that is, with genetically homogeneous plants. Under farm conditions the difference can be explained by the high variability of the ecological factors.

Conclusion

The results obtained by various kinds of mathematical calculation were found to be suitable for practical use. Our aim was to elaborate the simplest possible method of yield prediction for the use of farmers. With this in view we

Table 8

q/ha grain yield in the case of different spike number and length of spike. Winter wheats Bezostaya, Rannaya

Average length of spike, cm	Number of spikes per m²						
	300	350	400	450	500	550	600
5.0	22.5	25.8	28.8	31.8	34.6	37.2	39.7
5.2	23.4	26.9	30.0	33.1	36.0	38.8	41.4
5.4	24.4	27.9	31.2	34.4	37.5	40.3	43.1
5.6	25.3	29.0	32.5	35.8	38.9	41.9	44.7
5.8	26.3	30.0	33.7	37.1	40.4	43.4	46.4
6.0	27.2	31.1	34.9	38.4	41.8	45.0	48.1
6.2	28.2	32.2	36.1	39.8	43.3	46.6	49.8
6.4	29.2	33.3	37.4	41.2	44.8	48.2	51.5
6.6	30.1	34.5	38.6	42.5	46.2	49.8	53.2
6.8	31.1	35.6	39.9	43.9	47.7	51.4	54.9
7.0	32.1	36.7	41.1	45.3	49.2	53.0	56.6
7.2	33.1	37.8	42.3	46.7	50.7	54.6	58.3
7.4	34.0	38.9	43.6	48.0	52.2	56.2	60.0
7.6	35.0	40.0	44.8	49.4	53.7	57.9	61.8
7.8	35.9	41.1	46.1	50.7	55.2	59.2	63.5
8.0	36.9	42.2	47.3	52.1	56.7	61.1	65.2
8.2	37.9	43.3	48.6	53.5	58.2	62.7	66.9
8.4	38.9	44.5	49.9	54.9	59.7	64.4	68.7
8.6	39.9	45.6	51.1	56.3	61.3	66.0	70.4
8.8	40.9	46.8	52.4	57.7	62.8	67.7	72.2
9.0	41.9	47.9	53.7	59.1	64.3	69.3	73.9

constructed a table for each variety on the basis of total spike length and specific grain weight of the spike. At the head of the table the number of spikes per unit area is given, in the first column the average length of the spike, and at the point of intersection of the two data the yields per ha. In estimating the yield only the number of spikes per m² and their average length have to be established. On this basis the standing crop can be read from the table (Table 8). Besides its simplicity a further advantage of the method is its suitability for immediate application after heading, that is 4—5 weeks before harvesting.

When constructing the tables we took into consideration as a correction the change in the specific grain weight of the spike as a function of the average spike length and number of spikes per unit area.

The method was widely tested by practical farmers, and many of them sent reports on their experiences. Opinions on the method and on the tables published as aids to estimation were generally high. The tables have been widely applied and have resulted in less than 6% error, while in many farms the deviation was not more than 2—4%.

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INDUCED MUTATIONS AT EARLY STAGES OF ONTOGENESIS IN NIGELLA DAMASCENA L.

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Our method of treating gametes, zygotes and proembryos with chemical and physical mutagens is by all criteria superior to that of treating dry seeds. Treatment applied at early stages of ontogenesis not only induced a higher mutation ratio as compared with dry seeds but also gave a broader mutation spectrum. Fifthy-five types of hereditary changes were obtained affecting the structure of vegetative and generative organs. Mutations changing the structure of the generative organs are of particular interest. The optimum doses for the given object and method of treatment, which induces a high mutation ratio (up to 96% of families with changes), are EI — 0.003% (16 hr), and NMU — 0.005% and 0.008% (16 hr). The method of treating dry seeds turned out to be much less effective, being second to the treatment of gametes, zygotes and proembryos by all the criteria employed.

Introduction

The effect of chemical and physical mutagens on the growth and development of M_1 plants was shown (PHAN PHAI 1971a, b, PHAN PHAI—ANDREEV 1976). The present communication deals with data on the mutation ratio in M_2 after the treatment of early stages of embryogenesis.

The specific features of the plant developmental stage at which mutagens were applied resulted in a significant increase in the induced mutation ratio, and on the other hand made it possible to obtain peculiar mutants which did not appear after the treatment of dry seeds.

Materials and Methods

Nigella damascena L. *(Ranunculaceae)* was used. It has 6 pairs of chromosomes which are well distinguished morphologically.

The following mutagens were studied: X-irradiation (Xr), ethylenimine (EI), nitrozomethylurea (NMU), diethylsulphate (DES) and trimethylphosphate (TMP). Mutagens were applied to air-dried seeds, gametes, zygotes and embryos at early developmental stages (Table 1). Chemical mutagens were applied immediately after pollination, X-irradiation was carried out 4 hours after pollination (PHAN PHAI—ANDREEV 1976).

Seeds from changed and unchanged plants of M_1 were sown in families to obtain M_2. Fifty families were sown in each variant, 50 seeds in each family. The total number of families studied in M_2 was 1800, the number of M_2 plants was 83003. One hundred families, with 50 seeds in each, were sown for the control.

The mutation ratio was determined from the percentage of families with mutations and the percentage of mutant plants.

Table 1

Mutation ratio in M_2 of Nigella damascena L. after treatment of gametes, zygotes, proembryos and air-dried seeds with mutagens

Material treated	Mutagen	Variant	Dose (r) Concentration (%)	Exposure (hr)	Mutation ratio (%)	Ratio of families with mutations (%)
1	2	3	4	5	6	7
		Control (1)	—	—	0.12 ± 0.05	6.0 ± 2.37
Gametes, zygotes, proembryos	X-irradiation	Xr_1	300	—	1.93 ± 0.28	38.0 ± 6.86
		Xr_2	600	—	1.51 ± 0.36	40.0 ± 6.92
		Xr_3	900	—	5.21 ± 0.44	58.0 ± 6.97
		Xr_4	1200	—	2.21 ± 0.30	46.0 ± 7.04
		Average			3.21 ± 0.17	45.30 ± 7.04
	Ethylenimine	EI_1	0.003	8	2.87 ± 0.33	56.0 ± 7.01
		EI_2	0.005	8	4.13 ± 0.40	70.0 ± 6.47
		EI_3	0.008	8	7.61 ± 0.54	72.0 ± 4.50
		EI_4	0.003	12	8.35 ± 0.57	78.0 ± 5.85
		EI_5	0.005	12	9.63 ± 0.61	86.0 ± 4.90
		EI_6	0.008	12	11.84 ± 0.67	94.0 ± 3.35
		EI_7	0.003	16	18.55 ± 0.82	96.0 ± 2.77
		EI_8	0.005	16	6.48 ± 0.52	56.0 ± 7.01
		EI_9	0.008	16	6.12 ± 0.51	42.0 ± 6.97
		Average			8.35 ± 0.19	72.22 ± 6.33
	Nitrozomethylurea	NMU_1	0.008	8	2.23 ± 0.30	46.0 ± 7.04
		NMU_2	0.01	8	2.58 ± 0.31	46.0 ± 7.04
		NMU_3	0.005	12	4.36 ± 0.41	52.0 ± 7.06
		NMU_4	0.008	12	5.27 ± 0.45	60.0 ± 6.92
		NMU_5	0.01	12	6.31 ± 0.50	72.0 ± 6.34
		NMU_6	0.005	16	8.76 ± 0.58	82.0 ± 5.43
		NMU_7	0.008	16	10.33 ± 0.63	8.0 ± 4.59
		NMU_8	0.01	16	4.87 ± 0.44	44.0 ± 7.01
		Average			5.55 ± 0.16	61.25 ± 6.89
	Diethylsulphate	DES_1	0.05	8	1.88 ± 0.27	44.0 ± 7.01
		DES_2	0.1	8	2.79 ± 0.33	40.0 ± 6.92
		DES_3	0.05	12	3.28 ± 0.36	50.0 ± 7.07
		DES_4	0.1	12	5.91 ± 0.48	60.0 ± 6.92
		DES_5	0.05	16	7.32 ± 0.52	60.0 ± 6.92
		DES_6	0.1	16	7.38 ± 0.54	66.0 ± 6.69
		Average			4.83 ± 0.17	53.33 ± 7.06
	Trimethylphosphate	TMP_1	0.01	8	3.13 ± 0.34	38.0 ± 6.86
		TMP_2	0.01	12	7.21 ± 0.53	70.0 ± 6.47
		TMP_3	0.01	16	5.27 ± 0.47	50.0 ± 7.07
		Average			5.15 ± 0.26	52.66 ± 7.06

1	2	3	4	5	6	7
Air-dried seeds	X-irradiation	$Xr_1=DS_1$	9,000	—	2.03 ± 0.29	28.0 ± 6.02
		$Xr_2=DS_2$	12,000	—	1.25 ± 0.25	16.0 ± 5.18
		Average			1.68 ± 0.20	22.0 ± 5.56
	Ethylenimine	$EI=DS_3$	0.025	12	3.50 ± 0.38	32.0 ± 6.58
		$EI=DS_4$	0.025	18	9.03 ± 0.60	46.0 ± 7.04
		$EI=DS_5$	0.050	12	6.71 ± 0.54	44.0 ± 7.01
		$EI=DS_6$	0.050	18	2.65 ± 0.36	26.0 ± 6.20
		Average			4.12 ± 0.21	37.0 ± 6.83

(1) Normal seed buds without treatment.

Results

As Table 1 indicates, the offspring of plants treated with mutagens at early developmental stages showed twice as many mutations as after the treatment of dry seeds (both according to mean values obtained with all doses of a given mutagen and according to the maximum mutation ratio). It is interesting that the mutation ratio was almost equal after the application of either chemical or physical mutagens. The average ratio of families with mutations after the X-irradiation and EI-treatment of gametes, zygotes and proembryos was 45.50% and 72.22%, and when dry seeds were treated the ratio was 22.0% and 37.0% respectively.

These data also show that chemical mutagens are more effective than physical ones in all experiments. According to their ability to induce mutations in M_2, the mutagens used in our experiments can be arranged in the following sequence: EI > NMU > TMP > DES > Xr. This sequence does not depend on the method of registration.

Treatment with chemical mutagens applied at early stages of embryogenesis resulted in a high mutation ratio in M_2. The highest variability was observed for $EI_7 = 96.0 \pm 2.77\%$ and $NMU_7 - 88.0 \pm 4.59\%$, i.e. a change was revealed in almost every family.

After EI treatment of dry seeds, mutations were revealed in less than half of all the families studied ($EI–DS_4 - 46.0 \pm 7.04\%$).

Among the experimental variants with X-irradiation, the irradiation of zygotes and proembryos with a dose of 900 r turned out to be the most effective. The percentage of families with mutations after Xr_3 was $58.0 \pm 6.97\%$. With the increase of the dose to 1200 r the mutation ratio decreased ($Xr_4 - 46.0 \pm 7.04\%$). After the irradiation of dry seeds the maximum ratio of families with mutations only 28% ($Xr–DS_1 - 28.0 \pm 6.02\%$).

An analysis of the literature shows that in most cases chlorophyll mutations are not related to large chromosome aberrations, but are due to point

mutations or microaberrations (GUSTAFSSON 1938, BLIXT 1961, GOSTIMSKY 1966, 1971). Therefore the proportion of chlorophyll mutations can to some extent serve as a measure of the mutagen's ability to induce point mutations.

The investigation of the chlorophyll mutation ratio showed that the highest value was observed when chemical mutagens were applied at early stages of ontogenesis. The maximum number of families with chlorophyll mutations was induced by EI (EI_7 — 24.0 ± 6.04%) and NMU (NMU_7 — 20.0 ± 5.65%). With increased doses some tendency towards a drop in the ratio was observed (EI_9 and NMU_8 — 8.0 ± 3.82%).

When dry seeds were treated not only were less families with chlorophyll defects observed but also their proportion compared to the total number of all mutations decreased. Thus, after the EI treatment of proembryos, chlorophyll mutations in some variants (EI_6 and EI_7) comprised 1/4 of all mutations, while after the EI treatment of dry seeds their proportion did not exceed 15%. The same tendency was observed after X-irradiation.

Among the chemical mutagens used with gametes, zygotes and proembryos, TMP induced the smallest number of chlorophyll mutations (13.22 ± 6.59%). Thus an inverse relationship between the ability of mutagens to induce chromosome aberrations (PHAN PHAI—ANDREEV 1976) and the chlorophyll mutation ratio was observed.

Ten types of chlorophyll mutation were found after the effect of chemical mutagens at early stages of ontogenesis: albina, viridis, chlorina, virescens, xantha, xantha-virescens, vario-micromaculata, yellow-variegated, brown and blackening plants. Mutagens inducing more chlorophyll defects also turned out to induce the widest mutation spectrum (EI and NMU). Of the chemical mutagens the narrowest spectrum of chlorophyll mutations was induced by TMP (it was almost on the same level as that after X-irradiation).

Specific differences in the occurrence of certain types of chlorophyll mutations induced by various mutagens are of great interest. After EI treatment a reliable increase of the mutation "chlorina" was observed, whereas in NMU experiments a high peak for the mutation "xantha" was recorded.

Only after an appropriate genetic analysis can it be said whether a prevailing mutation of certain loci or a phenotypically similar realization of mutations of different genes was involved.

The effect of chemical and physical mutagens on gametes, zygotes and proembryos also induced, besides chlorophyll mutations, 45 types of morpho-physiological change. Four of these are concerned with the cotyledons (tricotyledonous, rounded and elongated cotyledonous and with a changed arrangement of the cotyledons); 3 types affect the leaves (small, hairlike, changed first and second leaves); 11 types affect the plant habitus (with fasciated stem, weakly branching, strongly branching, with short internodes, with thin stem, with long internodes, weakly developed, dwarf, full-grown); 3 types

Fig. 1. Normal flower of *Nigella damascena* L.

Fig. 2. Mutants of the generative organs after the treatment of gametes, zygotes and proembryos with different mutagens

affect the pink colouration (pink leaves and stem, brown, black); 17 types affect the flowers (long or short stamens and stigmas, elongated ovary, transformation of spathe leaflets into petals or follicles with open ovules, with transformation of petals into leaflets (Fig. 2), double-flowering (Fig. 3), with increased number of nectaries (Fig. 4), with transformation of stamens into leaflets with open ovules (Fig. 5), with transformation of various flower elements or all of them into leaves, etc.; 4 types affect the bolls (small, large,

Fig. 3. Mutants of the generative organs after the treatment of gametes, zygotes and proembryos with different mutagens

Fig. 4. Mutants of the generative organs after the treatment of gametes, zygotes and proembryos with different mutagens

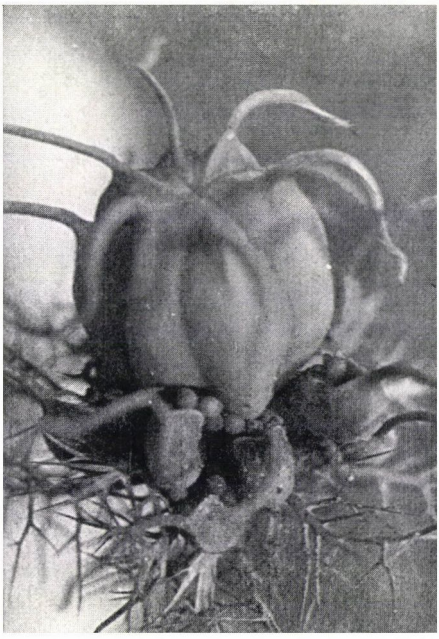

Fig. 5. Mutants of the generative organs after the treatment of gametes, zygotes and proembryos with different mutagens

changed, chimeric colouration of the bolls); 3 types affect the colouration of the seeds (white-black, brown and yellow).

Chemical mutagens induced the broadest spectrum of mutants; an increase in the number of various mutation types under the effect of alkalizing compounds being accompanied by an increase in the ratio of fertile types of mutant. The broadest spectrum of morphophysiological changes was obtained in M_2 after the EI treatment of gametes, zygotes and proembryos (43 types). NMU had the second largest number of types of morphophysiological change (37 types), whereas DES and TMP were significantly less potent (27 and 21 types respectively). After X-irradiation the spectrum of morphophysiological changes was narrower (18 types).

The narrowest spectrum of morphophysiological changes was obtained after the treatment of dry seeds (only 13 types after EI treatment and 8 types after irradiation). No mutation affecting the structure of the generative organs was observed in any of the experiments on dry seeds.

In many cases several mutations were obtained in M_2 within one family. The number of families with multiple changes increased with the increase (up to a certain limit) of the mutagen dose. It was greatest after the treatment of gametes, zygotes and proembryos with EI (EI_7 — $37.50 \pm 6.99\%$) and NMU (NMU_7 — $29.54 \pm 6.88\%$). After the treatment of dry seeds the

proportion of families with multiple changes was significantly lower ($Xr–DS_1$ — $14.28 \pm 9.35\%$).

Recently several authors have found a positive correlation between the number of chromosome aberrations and the depression of plant growth and development (CALDECOTT 1961, KHVOSTOVA 1965, KHVOSTOVA—ELSHUNI 1966).

Our data show that the growth, development and fertility of M_2 plants are correlated with the number of chromosome aberrations in embryo cells and the radicle meristem. However, the mutation ratio in M_2 is not directly proportional to that in M_1. Variants obtained at high mutagen doses which induced a strong disturbance of the chromosome structure in the embryo cells and greatly delayed the growth and development of M_1 plants showed a low percentage of mutations in M_2. A decrease in the number of families with multiple mutations and late mutations was also observed in these variants.

The analysis of the mutation ratio in M_2 induced after the treatment of zygotes, proembryos and dry seeds with different mutagens showed by all recording methods that chemical mutagens were superior to physical ones. This conclusion agrees well with the evidence obtained by other authors on other objects (EHRENBERG *et al.* 1961, EIGES 1965, SEMIN—VOITOVICH 1965).

It is well known that chromosome aberrations and visible mutations are two types of changes which can occur independently. To obtain more viable mutations it is necessary to decrease the number of large chromosome aberrations responsible for the disturbance of genic balance and cell death.

The great number of point mutations induced by chemical mutagens seems to be concerned with their greater ability to induce relatively "soft" changes of different loci. There are some data concerning greater selectivity of their effect on separate loci. It is also known that chemical mutagens induce less common and more varied mutations, which may also be connected with the total increase in the mutation ratio (EHRENBERG 1960, KHVOSTOVA *et al.* 1965, RAPPAPORT 1971).

When comparing the chlorphyll mutation ratio with the ratio of other morphophysiological mutations obtained in our experiments, it was found that the contribution of chlorophyll mutations to the overall mutability was higher after treatment at early stages of ontogenesis.

Morphophysiological mutations induced by chemical mutagens seem to be less concerned with chromosome aberrations than those induced by irradiation. This seems to account for the fact that more fertile mutations were observed after treatment with chemical mutagens than after irradiation.

Our method of treating gametes, zygotes and proembryos with chemical and physical mutagens is by all criteria superior to that of treating dry seeds. Treatment applied at early stages of ontogenesis not only induced a higher mutation ratio as compared with dry seeds but also gave a broader mutation

spectrum. Fifty-five types of hereditary changes were obtained, affecting the structure of vegetative and generative organs. Mutations changing the structure of the generative organs are of particular interest. Further investigations of the developmental genetics of these mutations will contribute to the solution of a number of theoretical (study of the origin of the flower and of some of its structures in *Angiospermae)* and practical problems. *Nigella damascena* L. can be used as a model for studying the possible increase in seed productivity in bisexual plants.

It is important to increase the available spectrum of mutations, because it enables a study to be made of the structure of a character; i.e. it permits a determination of the number of genes responsible for the development of the character studied, the sequence of their function in ontogenesis, and peculiarities of the interaction of these genes. A knowledge of the fine structure of a character will permit the construction of organisms with desirable characters and properties.

Our data show that the method of treating gametes, zygotes and proembryos is very effective in inducing mutations. The optimum dose for the given object and method of treatment, which induces a high mutation ratio (up to 96% of families with changes) is EI — 0.003% (16 hr), and NMU — 0.005% and 0.008% (16 hr). The method of treating dry seeds turned out to be much less effective, being second to the treatment of gametes, zygotes and proembryos by all the criteria employed.

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NUTRIENT CONTENT OF THROUGHFALL AND STEMFLOW WATER IN AN OAK-FOREST (QUERCETUM PETRAEAE-CERRIS) ECOSYSTEM

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The quantities of K, Ca, Na, Mg, Zn, Fe, S, N, Cl and P contained in the atmospheric precipitation, as well as in throughfall and stemflow water, were studied for a year in a forest ecosystem of the Hungarian climatic zone. The monthly and annual quantities of each element reaching the ground with the precipitation water over one hectare of forest were determined. The power function relations between the quantities and element concentrations of throughfall water and atmospheric precipitation were established.

Introduction

In an oak-forest *(Quercetum petraeae-cerris)* of a climatic zone highly characteristic of the Hungarian regions complex research work is in progress within the framework of the MAB-programme ("Síkfőkút Project", see Jakucs 1973), which includes investigations into the water and mineral cycle of forests. Our investigations are concerned with that section of the water circulation in the ecosystem in which the rainwater passes through various layers of the forest before reaching the ground (Szabó 1975).

For some ten years increased attention has been paid all over the world to investigations on the amount of nutrients introduced with the precipitation into various ecosystems, and on the mineral content of throughfall water (Madgwick—Ovington 1959, Mina 1965, Carlisle *et al.* 1966, Cole *et al.* 1967, Ovington 1968, Rapp 1969, Denaeyer-De Smet 1969, Ulrich *et al.* 1971, Kozák—Mészáros 1971a, 1971b, Reiners 1972, Gubareva 1973, etc.). It has been demonstrated that the water and mineral circulations of forest ecosystems are always closely related (Bormann—Likens 1967, Pomeroy 1970).

The precipitation water reaches the ground of the forest enriched to a greater or lesser extent with nutrients obtained by washing off the dust deposited on the leaves, branches and trunks, and by leaching the bioelement content of living plant tissues (Tamm 1958, Stenlid 1958, Tukey 1970).

Although the larger part of the nutrients is returned to the soil through the decomposition of forest litter, the rainwater falling through the foliage and running down the trunks is nevertheless of great importance primarily

in returning the potassium: some 50 per cent of the amount taken up is returned to the soil in this way every year (DUVIGNEAUD *et al.* 1971, NEBE 1973). Apart from potassium, a considerable proportion of the magnesium is returned to the soil with the rainwater.

The present paper gives the summarized results of a one-year investigation into the total amount of nutrient reaching the ground with the rainwater in the forest under examination. For details of the annual trend of bioelement content in throughfall water alone, see SZABÓ—CSORTOS (1975). Here detailed analysis data of the stemflow water are presented. This water represents only a small proportion (0—5.5 per cent) of the total amount of rain water reaching the soil (SZABÓ 1975), yet its analysis should not be neglected, because water reaching the ground in this way is usually considerably enriched with mineral substances and may have a great influence on the water and nutrient content of the soil within a radius of 0.5 m from the tree (VOIGT 1960, MINA 1967, DENAEYER-DE SMET 1969, WITKAMP 1971, SIMON 1974).

Material and Method

The investigations were carried out in a 65—70 year old, homogeneous, second-growth mixed oak–turkey oak forest in hilly country where the Central Mountains of Northern Hungary give way to the Great Hungarian Plain. In the tree stratum of the forest stand *Quercus petraea* is the dominant species (84 per cent) mixed with *Quercus cerris* (16 per cent). The degree of closeness of the foliage is 80 per cent, the average height 17.3 m, and the average trunk diameter 20 cm. The hectare examined contained 816 trees. The forest has a well developed shrub stratum with large quantities of *Cornus mas*, *Acer campestre*, *A. tataricum*, *Ligustrum vulgare*, etc. For a detailed analysis of the structure, surroundings and climate of the forest examined, see the papers of JAKUCS (1973) and JAKUCS *et al.* (1975).

Samples were generally taken every two weeks, sometimes every week between 27th February and 4th December 1974, on a total of 23 occasions. For the annual trend of precipitation reaching the forest ground (canopy throughfall and stemflow water) and of interception see SZABÓ (1975).

Atmospheric precipitation was caught in polyester troughs, each with a collection surface of 2000 cm^2 fixed on the top of a tower reaching beyond the foliage, and canopy throughfall was collected in similar troughs attached to stands 1 m in height placed on the forest ground, over a quarter of a hectare of the model area marked out for this purpose. The water was collected in black plastic cans. Canopy throughfall was studied in four combinations (under *Quercus petraea*, *Qu. cerris*, *Qu. petraea* + *Cornus mas* and *Qu. petraea* + *Acer campestre)* and 14 replications (SZABÓ—CSORTOS 1975). To collect stemflow water polyurethane rings were fixed to the trunks at a height of 130 cm in 2 combinations *(Qu. petraea* and *Qu. cerris)* and 14 replications. The use of polyurethane foam for catching precipitation running down the trunk was reported by LIKENS—EATON (1970). The water, here too, was collected in black plastic cans.

It is known that nitrogen and phosphorus contained in the water are readily incorporated into microorganisms. To prevent this, we poured thymol into the collecting cans after each sampling. According to our observations the thymol method is less elaborate than the preventive iodine treatment used by HERON (1962) and gives reliable results.

For the monthly determination 500 ml samples of well homogenized rain water were used, which were kept in a refrigerator until they were required for the analysis. As water samples were taken more frequently than once a month, the samples were mixed proportionately to the amounts collected and the mixed samples were analysed for K, Na, Ca, Mg, Zn, Fe, Mn, SO_4—S, PO_4—P, NO_3—N, Kjeldahl-N and Cl.

The cations were determined with a UNICAM SP 1900-type atom-absorption spectrophotometer at the Institute of Inorganic Chemistry of the Kossuth University, Debrecen.

The organic nitrogen was measured by the Kjeldahl method. After destruction, the NH_3 content of the sample was distilled in a modified Parnass—Wagner apparatus into a 2 per cent solution of H_3BO_3 and acidimetrically measured.

The phosphorus forms contained in the water samples were first transformed into ortho-phosphate by Kjeldahl destruction, then, after adding molybdate-sulphuric acid reagent, they were photometrically measured at a wavelength of 665 nm.

Nitrate and sulphate were also determined by colorimetry. In an acidic medium the NO_3-ions give a yellow colour with Na-salicylate; the colour intensity was measured at 420 nm. Sulphate determination was carried out in the following way: the SO_4-ions were precipitated with a known quantity of $BaCl_2$ solution, then the surplus Ba was measured with the aid of a K_2CrO_4 solution at 400 nm.

Chloride determination was performed with an OP-Cl-7112-D type chloride-selective electrode using a pH-meter.

Results

The quantities of the 11 elements examined in the atmospheric precipitation as well as in the canopy throughfall and stemflow water were analysed using samples, then averaged for each combination; subsequently we worked with these mean values. We calculated a so-called enrichment factor for each element, which expressed how many times the concentration of the element in the throughfall and stemflow waters increased compared to that in the atmospheric precipitation. Since the annual trend of the mineral content of canopy throughfall was published earlier in detail (SZABÓ—CSORTOS 1975), here we only discuss the stemflow water and give summarized results for the whole forest stand.

The nutrient quantities per ha reaching the forest ground with the stemflow water were computed taking into account the element concentrations, water quantities and the foliage coverage values of the stem concerned. These data are summed up in Table 1 according to months, species and years. The table also gives the concentration of the elements in the atmospheric precipitation, and the enrichment factors. The data clearly show the increased concentration of the stemflow water reaching the ground, as compared to the nutrient content of the atmospheric precipitation. Our data unambiguously prove that the concentration of elements in the water running down the trunks of *Quercus cerris* trees is always lower than that in the stemflow waters of *Qu. petraea* trees. The differences are clearly seen in Figs 1a and b.

The stemflow water is particularly enriched in mobile cations as demonstrated by CARLISLE *et al.* (1967), NIHLGÅRD (1970) and also by our own measurements. In our investigations stemflow water was enriched to a much greater extent than canopy throughfall, particularly with respect to potassium, calcium, manganese and sulphur. The maximum enrichment factors for these elements in the above order were 118.3, 41.6, 170.0 and 34.2 (Table 1).

It is interesting that the nitrogen concentration of the stemflow water is at its highest in the spring, as is the nitrogen content of throughfall water. These maxima coincide with the time of caterpillar gradation in the forest.

Table 1

Mineral contents of atmospheric precipitation and stemflow water in the

Date	Type of precipitation	Amount of precipitation, mm	K			Ca			Mg		
			a	b	c	a	b	c	a	b	c
	A	4.3	1.3	0.0440		6.0	0.2100		0.64	0.0220	
27. 2.—	B—1	0.1	7.2	0.0009	5.7	23.2	0.0026	3.9	3.75	0.0004	5.8
13. 3.	B—2		16.7	0.0014	13.2	36.2	0.0020	6.0	4.54	0.0003	7.1
	A	78.6	1.7	1.3200		1.8	1.3590		0.14	0.1100	
24. 4.—	B—1	2.3	46.8	0.2889	24.8	72.0	0.5296	41.6	7.05	0.0471	50.4
22. 5.	B—2		28.2	0.0533	16.8	18.3	0.0580	10.6	1.94	0.0064	13.7
	A	104.6	4.0	4.1820		1.5	1.5890		0.16	0.1670	
22. 5.—	B—1	3.0	22.4	0.3526	5.6	23.8	0.3678	15.7	1.88	0.0314	11.7
19. 6.	B—2		13.7	0.0658	3.4	6.7	0.0309	4.3	0.78	0.0036	4.8
	A	40.3	1.0	0.3970		6.0	2.3830		1.01	0.4010	
19. 6.—	B—1	0.9	19.7	0.0664	19.7	30.0	0.0757	5.0	3.73	0.0081	3.7
31. 7.	B—2		16.4	0.0199	16.4	18.9	0.0188	3.2	2.26	0.0025	2.2
	A	90.1	0.2	0.1350		2.8	2.4770		0.23	0.2070	
31. 7.—	B—1	2.5	17.8	0.2079	18.3	25.6	0.2891	9.3	5.41	0.0746	23.5
29. 8.	B—2		12.5	0.0059	83.3	14.1	0.0660	5.1	2.98	0.0143	13.0
	A	52.9	0.4	0.2110		2.0	1.0580		0.18	0.0950	
29. 8.—	B—1	1.5	27.7	0.1520	69.3	28.5	0.1814	14.3	2.19	0.0153	12.2
2. 10.	B—2		16.9	0.0251	42.3	9.6	0.0099	4.8	2.11	0.0019	11.7
	A	194.0	0.5	0.9920		3.6	7.1460		0.61	1.2110	
2. 10.—	B—1	6.6	13.8	0.3889	27.7	14.3	0.4560	4.0	1.31	0.0400	2.1
30. 10.	B—2		7.3	0.0678	14.7	9.0	0.0801	2.5	0.75	0.0065	1.2
	A	27.1	0.3	0.0700		3.0	0.8180		0.18	0.0480	
30. 10.—	B—1	1.5	15.7	0.0583	60.3	25.9	0.1054	8.6	3.41	0.0128	18.9
4. 12.	B—2		11.1	0.0071	42.7	14.8	0.0095	4.9	2.60	0.0015	14.4
Σ	A	595.3		7.4400			17.4100			2.3100	
27. 2.—	B—1	18.4		1.5157			2.0077			0.2298	
4. 12.	B—2			0.2462			0.2753			0.0370	

forest examined between 27th February and 4th December 1974

Na			Mn			Zn		
a	b	c	a	b	c	a	b	c
0.46	0.0160		0.12	0.0040		0.04	0.0013	
2.55	0.0002	5.6	2.33	0.0004	19.4	0.16	0.0001	4.3
2.13	0.0001	4.7	2.39	0.0002	19.9	0.22	0.0001	6.0
0.47	0.3690		0.10	0.0790		0.03	0.0212	
1.90	0.0170	4.1	5.24	0.0382	52.4	0.15	0.0013	5.6
1.30	0.0044	2.8	1.22	0.0107	12.2	0.12	0.0003	4.3
0.25	0.2610		0.01	0.0100		0.04	0.0366	
0.94	0.0187	3.8	1.46	0.0209	145.8	0.11	0.0018	3.1
0.56	0.0026	2.3	0.55	0.0025	54.8	0.09	0.0004	2.5
0.42	0.1670		0.02	0.0080		0.00	0.0000	
1.49	0.0055	3.6	0.84	0.0027	41.8	0.10	0.0004	103.4
1.10	0.0012	2.6	0.71	0.0006	35.7	0.13	0.0001	128.0
0.10	0.0900		0.02	0.0180		0.01	0.0045	
0.43	0.0054	4.3	0.62	0.0080	30.9	0.08	0.0010	8.0
0.42	0.0014	4.2	0.60	0.0025	29.8	0.08	0.0003	8.0
0.41	0.2170		0.05	0.0260		0.05	0.0265	
0.82	0.0067	2.0	0.45	0.0101	28.9	0.10	0.0010	2.0
0.68	0.0004	1.7	1.00	0.0009	20.0	0.09	0.0001	1.8
0.13	0.2580		0.01	0.0200		0.01	0.0238	
0 49	0.0174	3.7	0.57	0.0187	56.5	0.06	0.0033	6.0
0.35	0.0030	2.7	0.43	0.0020	42.9	0.05	0.0004	5.0
0.25	0.0680		0.02	0.0040		0.05	0.0143	
0.64	0.0025	2.6	2.55	0.0111	170.0	0.08	0.0009	1.6
0.59	0.0005	2.4	2.07	0.0011	137.9	0.10	0.0001	1.9
	1.4600			0.1700			0.1300	
	0.0734			0.1102			0.0091	
	0.0137			0.0204			0.0018	

(Continued overleaf)

Table I

Date	Type of precipitation	Amount of precipitation, mm	Fe			SO_4–S		
			a	b	c	a	b	c
	A	4.3	0.04	0.0014		9.4	0.3290	
27. 2.—	B—1	0.1	0.19	0.0001	4.8	27.9	0.0029	2.9
13. 3.	B—2		0.35	0.0001	8.9	51.6	0.0047	5.5
	A	78.6	0.01	0.0078		5.1	4.0270	
24. 4.—	B—1	2.3	0.18	0.0016	18.0	93.0	0.8229	18.2
22. 5.	B—2		0.22	0.0007	22.4	52.2	0.1679	10.2
	A	104.6	0.05	0.0523		2.1	2.2140	
22. 5.—	B—1	3.0	0.17	0.0029	3.4	72.3	1.1292	34.2
19. 6.	B—2		0.14	0.0008	2.9	34.9	0.1620	16.5
	A	40.3	0.01	0.0039		7.8	3.1040	
19. 6.—	B—1	0.9	0.12	0.0005	12.1	40.5	0.1121	5.2
31. 7.	B—2		0.06	0.0001	5.6	33.9	0.0340	4.3
	A	90.1	0.02	0.0180		3.3	2.9750	
31. 7.—	B—1	2.5	0.14	0.0015	7.0	27.8	0.2964	8.4
29. 8.	B—2		0.13	0.0005	6.5	27.1	0.0905	8.2
	A	52.9	0.02	0.0106		3.4	1.7710	
29. 8.—	B—1	1.5	0.15	0.0011	7.5	83.9	0.4289	25.1
2. 10.	B—2		0.15	0.0002	7.5	35.1	0.0415	10.5
	A	194.0	0.0	0.0		9.0	1.9420	
2. 10.—	B—1	6.6	0.0	0.0		60.8	1.4505	6.8
30. 10.	B—2		0.0	0.0		28.3	0.2545	3.2
	A	27.1	0.0	0.0		3.5	0.9560	
30. 10.—	B—1	1.5	0.0	0.0		69.9	0.2430	19.8
4. 12.	B—2		0.0	0.0		33.5	0.0200	9.5
Σ	A	595.3		0.0900			17.8300	
27. 2.—	B—1	18.4		0.0076			4.4860	
4. 12.	B—2			0.0024			0.7752	

continued

Total-N			Cl			PO_4–P		
a	b	c	a	b	c	a	b	c
5.2	0.1820		4.6	0.1630		0.22	0.0175	
22.2	0.0021	4.3	10.3	0.0013	2.2	1.07	0.0001	5.0
31.9	0.0027	6.1	19.8	0.0008	4.2	1.00	0.0001	4.6
2.8	2.2270		2.1	1.6160		0.18	0.1439	
21.6	0.1924	7.6	15.5	0.1157	7.5	0.85	0.0082	4.6
12.8	0.0440	4.5	7.2	0.0259	3.5	0.43	0.0019	2.3
1.9	2.0840		2.1	2.1490		0.11	0.1150	
3.5	0.1212	1.7	5.2	0.0921	2.5	0.31	0.0056	2.8
2.3	0.0104	1.1	3.3	0.0162	1.6	0.36	0.0020	3.3
2.7	1.0570		2.8	1.0980		0.68	0.2712	
8.9	0.0272	3.4	8.5	0.0335	5.1	1.16	0.0040	1.7
5.0	0.0137	1.9	7.4	0.0083	2.7	1.07	0.0022	1.6
6.2	5.6220		1.7	1.5010		0.34	0.3064	
4.3	0.0554	0.7	4.0	0.0525	1.8	0.45	0.0062	1.3
5.3	0.0221	0.9	4.1	0.0177	2.4	0.37	0.0016	1.1
5.1	2.6960		2.3	1.2080		0.34	0.1775	
9.2	0.0677	1.8	4.5	0.0440	2.0	0.63	0.0056	1.9
8.9	0.0112	1.7	4.9	0.0066	2.2	0.65	0.0008	1.9
2.5	5.0280		2.3	4.5330		0.14	0.2717	
6.1	0.2037	2.4	2.2	0.0548	1.0	0.48	0.0164	3.5
3.4	0.0286	1.4	2.3	0.0127	1.0	0.42	0.0041	3.0
3.3	0.9000		1.3	0.3610		0.08	0.0200	
4.5	0.0246	1.4	5.1	0.0195	3.8	0.28	0.0009	3.7
6.3	0.0047	1.9	4.4	0.0023	3.3	0.38	0.0002	4.9
	20.0900			12.6200			1.3200	
	0.6943			0.4136			0.0470	
	0.1375			0.0906			0.0128	

A = atmospheric precipitation
B—1 = stemflow water of *Quercus petraea*
B—2 = stemflow water of *Quercus cerris*
a = concentration — mg/litre
b = mineral content — kg/ha
c = enrichment factor — $\frac{\text{concentration of stemflow water}}{\text{concentration of atmospheric precipitation}}$

In the period between 13th March and 24th April stemflow water was 0.00 mm.

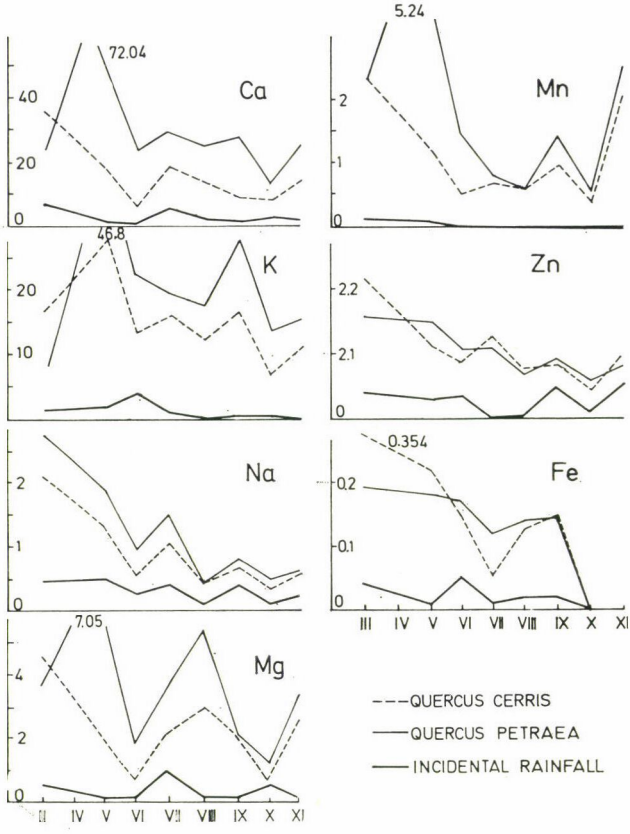
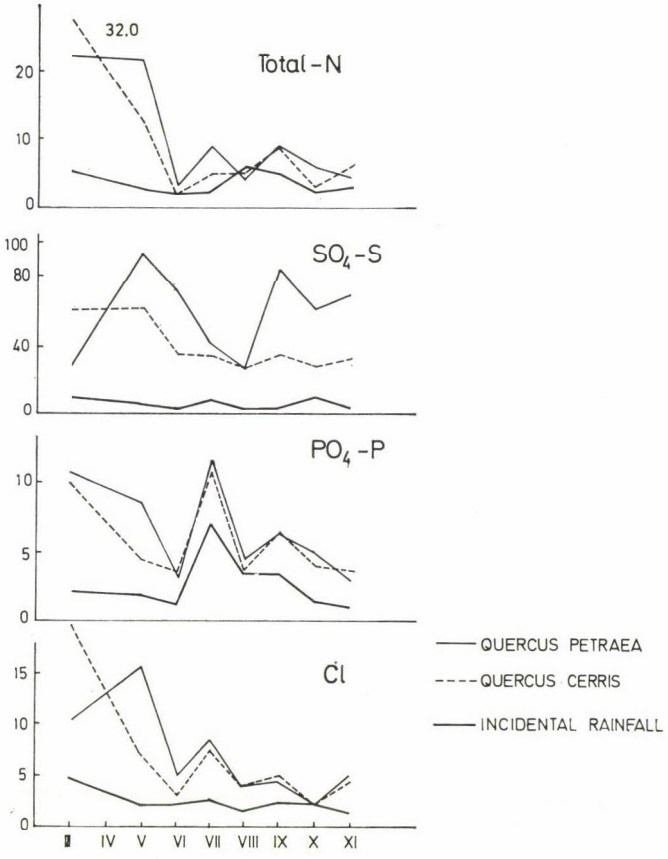


Fig. 1. Trends of element concentration in atmospheric

Analyses indicated a very high organic nitrogen content in the caterpillar excrements, and this effect could also be observed in the water samples.

Table 2 contains the total monthly and yearly precipitation input of minerals into the ecosystem, as well as the nutrient content of canopy throughfall and stemflow water. The quantity of water collected is also given in the table in mm. At an atmospheric precipitation of 593.3 mm, the rainwater retention of the forest during the period of investigation was 120.3 mm (20.1 per cent), the canopy throughfall was 456.6 mm (76.8 per cent) and the stemflow water 18.4 mm (3.1 per cent). Water which passed through the vegetation contained a remarkably large amount of potassium and sulphate-sulphur (the increase was 21.34 and 35.50 kg/ha, respectively), but its nitrogen content decreased on a yearly average (—1.98 kg/ha). Similar observations were made by CARLISLE *et al.* (1967), DENAEYER-DE SMET (1969) and ULRICH



precipitation and stemflow water (mg/litre)

et al. (1971) in oak and beech forests. The decrease may be caused by the fact that inorganic nitrogen compounds — mainly nitrates — are first absorbed from rainwater which falls onto the surface of the leaves (STENLID 1958).

The total amount of nutrients reaching the soil with the rainwater is shown in Fig. 2. For each element the amount entering the forest with the atmospheric precipitation is represented by the empty upper part, and that reaching the ground in different ways by the lower part. For the quantities reaching the ground, the transversally lined part represents the mineral content of water passing through the foliage and of that which falls through the gaps in the canopy. The latter was computed taking into consideration the foliage coverage value (80 per cent); that is, in the forest concerned there is 20 per cent of open surface through which the atmospheric precipitation (and its nutrient content) can reach the soil practically unhindered. It should

Table 2

Nutrient contents of atmospheric precipitation, canopy throughfall

Date	Type of precipitation	Amount of precipitation mm	K	Ca	Mg	Na
	A	4.3	0.0440	0.2100	0.0220	0.0160
27. 2.—	B	3.6	0.0540	0.2400	0.0240	0.0260
13. 3.	C	0.1	0.0023	0.0046	0.0007	0.0003
	D	−0.6	+0.0123	+0.0346	+0.0027	+0.0103
	A	3.3	0.0830	0.3600	0.0470	0.0180
13. 3.—	B	1.4	0.2220	0.3750	0.0730	0.0150
24. 4.	C	0.0	0.0	0.0	0.0	0.0
	D	−1.9	+0.1390	+0.0150	+0.0260	−0.0030
	A	78.6	1.3200	1.3590	0.1100	0.3690
24. 4.—	B	60.3	6.5600	1.7390	0.5820	0.5960
22. 5.	C	2.3	0.3422	0.5876	0.0535	0.0214
	D	−15.4	+5.5822	+0.9676	+0.5235	+0.2484
	A	104.6	4.1820	1.5890	0.1670	0.2610
22. 5.—	B	81.0	6.7820	2.3080	0.7720	0.2620
19. 6.	C	3.0	0.4184	0.3987	0.0350	0.0213
	D	−20.6	+3.0184	+1.1177	+0.6400	+0.0223
	A	40.3	0.3970	2.3830	0.4010	0.1670
19. 6.—	B	27.1	3.4510	3.9170	0.8760	0.2190
31. 7.	C	0.9	0.0863	0.0945	0.0106	0.0067
	D-	−12.3	+3.1403	+1.6285	+0.4856	+0.0587
	A	90.1	0.1350	2.4770	0.2070	0.0900
31. 7.—	B	64.9	1.9520	6.3710	0.8830	0.1870
29. 8.	C	2.5	0.2138	0.3551	0.0889	0.0068
	D	−22.7	+2.0308	+4.2491	+0.7649	+0.1038
	A	52.9	0.2110	1.0580	0.0950	0.2170
29. 8.—	B	38.7	1.6270	2.3570	0.3260	0.1900
2. 10.	C	1.9	0.1771	0.1913	0.0172	0.0071
	D	−12.3	+1.5931	+1.4903	+0.2482	−0.0199
	A	194.0	0.9920	7.1460	1.2110	0.2580
2. 10.—	B	157.5	5.2550	4.3570	0.8230	0.2470
30. 10.	C	6.6	0.4567	0.5361	0.0465	0.0204
	D	−29.9	+4.7197	−2.2529	−0.3415	+0.0094
	A	27.1	0.0700	0.8180	0.0480	−0.0680
30. 10.—	B	23.3	1.1140	1.6070	0.1870	0.1000
4. 12.	C	1.5	0.0654	0.1149	0.0143	0.0030
	D	−2.3	+1.1094	+0.1938	+0.1533	+0.0350
Σ	A	595.3	7.44	17.41	2.31	1.46
27. 2.—	B	456.6	27.02	23.28	4.55	1.84
4. 12. 1974	C	18.4	1.76	2.28	0.27	0.09
	D	−120.3	+21.34	+8.15	+2.51	+0.47

A = atmospheric precipitation, B = canopy throughfall, C = stemflow water, D = difference (B+C)−A, n.a. = not analysed

and stemflow water in the forest examined, in kg/ha

Mn	Zn	Fe	SO_4-S	Total-N	Cl	PO_4-P
0.0040	0.0013	0.0014	0.3290	0.1820	0.1630	0.0175
0.0090	á.0014	0.0031	0.3810	0.2360	0.1190	0.0237
0.0006	0.0002	0.0002	0.0076	0.0048	0.0021	0.0002
+0.0056	+0.0003	+0.0019	+0.0596	+0.0578	−0.0419	+0.0064
0.0030	0.0009	0.0002	0.5170	0.3000		0.0113
0.0170	0.0015	0.0017	0.5140	0.2850	n. a.	0.0316
0.0	0.0	0.0	0.0	0.0		0.0
+0.0140	+0.0006	+0.0015	−0.0030	−0.0150		+0.0203
0.á790	0.0212	0.0078	4.0270	2.2270	1.6160	0.1439
0.3090	0.0239	0.0368	13.8860	4.3540	2.1590	0.6419
0.0489	0.0016	0.0023	0.9908	0.2364	0.1416	0.0101
+0.2789	+0.0043	+0.0313	+10.8498	+2.3634	+0.6846	+0.5082
0.0100	0.0366	0.0523	2.2140	2.0480	2.1490	0.1150
0.2610	0.0650	0.0778	5.5220	1.7910	2.1540	0.1916
0.0234	0.0022	0.0037	1.2912	0.1316	0.1083	0.0076
+0.2744	+0.0306	+0.0292	+4.5992	−0.1614	+0.1133	+0.0842
0.0080	0.0004	0.0039	3.1040	1.0570	1.0980	0.2712
0.1060	0.0247	0.0247	2.9760	1.1590	1.5200	0.1824
0.0033	0.0005	0.0006	0.1461	0.0409	0.0418	0.0062
+0.1013	+0.0273	+0.0214	+0.0181	+0.1429	+0.4638	−0.0825
0.0180	0.0045	0.0180	2.9750	5.6220	1.5010	0.3064
0.0880	0.0221	0.0343	2.3980	2.7720	1.4400	0.2919
0.0105	0.0013	0.0020	0.3869	0.0775	0.0702	0.0078
+0.0805	+0.0189	+0.0183	−0.1901	−2.7725	+0.0092	−0.0067
0.0260	0.0265	0.0106	1.7710	2.6960	1.2080	0.1775
0.1380	0.0179	0.0079	3.9200	1.8900	1.6670	0.1800
0.0110	0.0011	0.0013	0.4704	0.0789	0.0506	0.0064
+0.3090	−0.0075	−0.0013	+2.6194	−0.7271	+0.8096	+0.0089
0.0200	0.0238	0.0	1.9420	5.0280	4.5330	0.2717
0.3180	0.0382	0.0	13.9710	3.7930	3.2300	0.4461
0.0207	0.0037	0.0	1.7050	0.2323	0.0675	0.0205
+0.3187	+0.0181		+13.7340	−1.0027	−1.2355	+0.1949
0.0040	0.0143	0.0	0.9560	0.9000	0.3610	0.0200
0.1450	0.0100	0.0	2.5910	1.0010	0.5980	0.0930
0.0122	0.0004	0.0	0.2630	0.0293	0.0218	0.0011
+0.1532	−0.0039		+1.8980	+0.1303	+0.2588	+0.0741
0.17	0.12	0.09	17.83	20.09	12.62	1.32
1.39	0.21	0.18	46.07	17.28	12.88	2.07
0.13	0.01	0.01	5.26	0.83	0.51	0.06
+1.35	+0.10	+0.10	+33.50	−1.98	+0.77	+1.35

Table 3

Results of investigations into the precipitation conditions of

Author	Place	Forest type	Annual amount of precipitation, mm	
MADGWICK—OVINGTON 1959	Bedgebury S. E. England	Hardwoods		a
			840	b
		Softwoods		b
MILLER 1963	New-Zealand	Beech (Nothofagus)		a
			1335	b
MINA+ 1965	U.S.S.R S. taiga	*Picea abies*		a
			273	b
		Pinus silvestris		b
ATTIWILL 1966	S.E. Australia	*Eucalyptus obligua*	979	a
				b
CARLISLE *et al.* 1966—67	England	*Quercus petraea*	1617	a
				b
				c
COLE *et al.* 1967	Washington U.S.A.	Douglas-fir	1360	a
				b
				c
DENAEYER-DE SMET 1969	Virelles-Blaimont Belgium	Mixed oak forest	865	a
				b
				c
		Madeleine *Quercus ilex*	477	a
				b
		Rouquet *Quercus ilex*	662	a
RAPP 1969	S. France			b
		Grabels *Pinus halepensis*	601	a
				b
		Gabriac *Qu. lanuginosa*	709	a
				b
NIHLGÅRD 1970	Scania S. Sweden	Beech *(Fagus silvatica)*		a
				b
			950	c
		Spruce *(Picea abies)*		b
				c
ULRICH *et al.* 1971	Solling Project W. Germany	Luzulo-Fagetum		a
			1088	b
				c
REINERS 1972	Cedar Creek E. Minnesota	Oak		b
		Fen	624	b
		Swamp		b
Present study++	Sikfőkút Project, Hungary	Oak *(Quercus petraea)*		a
			595	b
				c

a = incidental rainfall
b = throughfall
c = stemflow

various forest types (on the basis of literary data)

Nutrient content — kg/ha/year								
K	Ca	Mg	Na	Mn	S	N	P	Cl
2.8	10.7	4.2	19.3					
27.8	24.5	11.0	31.1					
22.6	24.1	8.8	33.8					
5.8	6.4	9.9	55.2		7.4	2.1	0.20	102.5
27.3	11.8	11.8	65.0		9.2	2.5	0.50	140.0
5.1	6.6	1.6				1.0		
9.5	6.5	2.4				0.9		
7.0	8.4	1.6				3.3		
1.8	2.2	5.1	17.3					
13.4	8.0	7.3	25.4					
3.0	7.3	4.6	35.3			9.5	0.43	
28.1	18.2	9.4	55.5			8.8	1.31	
1.6	2.0	0.7	5.9			0.1	0.01	
0.8	2.8					1.1	traces	
10.7	3.5					1.5	0.30	
1.6	1.1					0.2	0.10	
5.0	19.3		25.4			8.0*		
20.7	23.0		22.6			9.2*		
1.7	3.4		2.8			0.7*		
3.1	14.7	2.1	22.9			14.3	0.70	
40.7	37.9	6.9	42.9			23.9	3.80	
2.0	10.5	1.5	22.6			14.6	1.00	
21.3	26.3	2.7	34.1			14.2	2.10	
3.8	10.2	1.7	19.1			14.6	0.80	
12.8	21.7	4.4	39.6			15.7	1.40	
3.8	11.7	1.0	13.4			12.4	1.10	
16.5	13.3	3.4	22.7			16.5	1.30	
1.9	3.5	0.9	5.6	0.10	7.9	8.2	0.07	11.1
9.9	9.0	3.0	13.7	1.93	14.9	8.5	0.11	31.2
3.2	1.1	0.4	2.0	0.22	3.6	0.4	0.01	4.3
22.6	14.7	5.3	22.6	4.03	42.0	21.5	0.43	46.3
4.5	2.7	0.9	3.6	0.52	12.2	2.6	0.07	8.6
2.0	12.4	1.8	7.3	0.22	24.8	23.9	0.48	17.8
18.1	26.6	3.5	11.3	2.81	40.8	22.5	0.58	38.0
7.5	5.8	0.7	2.3	0.88	16.5	2.6	0.02	6.5
	7.6	3.1				5.5	0.70	
	10.5	3.8				5.5	0.60	
	10.7	3.7				6.0	0.50	
7.4	17.4	2.3	1.5	0.17	17.8	20.1	1.32	12.6
27.0	23.3	4.6	1.8	1.39	46.1	17.3	2.07	12.9
1.8	2.3	0.3	0.1	0.13	5.3	0.8	0.06	0.6

+ data refer to a single period of vegetation (13.6.—12.9.)
++ data refer to a single period of vegetation (27.2.—4.12.)
* only NO_3—N was measured

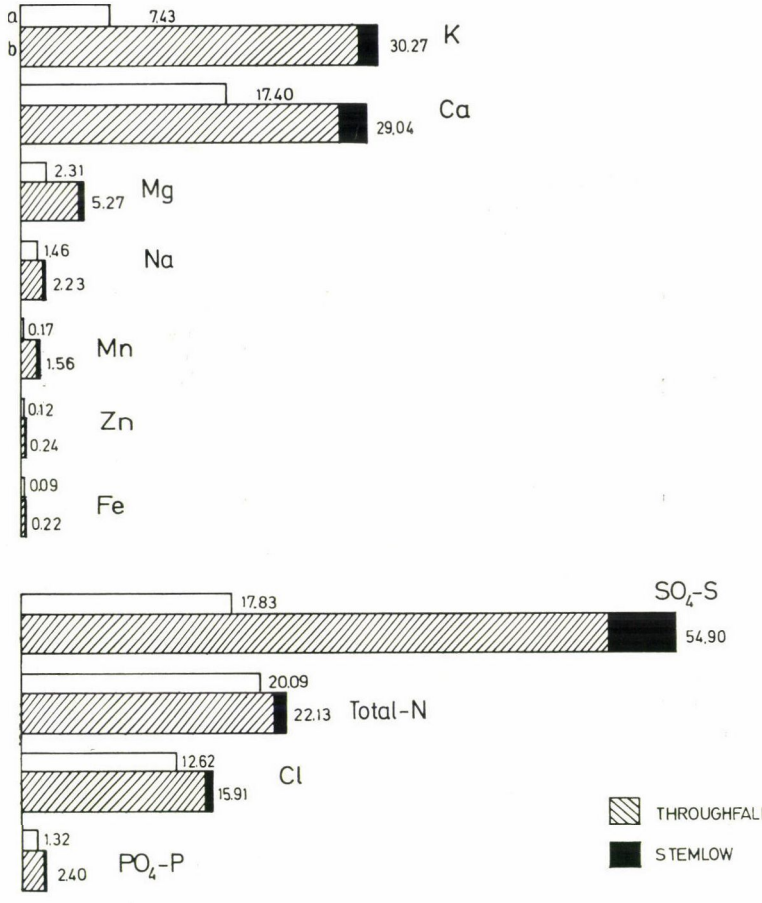


Fig. 2. Nutrient contents of *(a)* atmospheric precipitation and *(b)* water reaching the ground (kg/ha/year)

be mentioned here that the values obtained for the atmospheric precipitation — with the exception of the low sodium and relatively high phosphorus values — fit in well with the general conditions in Hungary (KOZÁK—MÉSZÁROS 1971a).

For the purposes of comparison, the results of precipitation studies carried out in different types of forest are summed up in Table 3 on the basis of literary data. The table reveals that our data approximate to results obtained in similar types of forest (see MADGWICK—OVINGTON 1959, CARLISLE *et al.* 1966, 1967, DENAEYER-DE SMET 1969, ULRICH *et al.* 1971). Large differences are only found in the amount of sodium in both the atmospheric precipitation and the canopy throughfall. This can be explained by the fact that the sodium concentration (and the chloride content) of the rainwater is deter-

mined to a considerable extent by the distance of the experimental site from the sea. The investigations mentioned — in contrast to those carried out in Hungary — were performed in forests near the sea (England, Belgium).

Relationship between the amount of precipitation and the concentration of the elements. According to LARSON—HETTICK (1956) the amount (X) of rainwater and its ion concentration (Y) show the following relation:

$$Y = a - bX$$

where a and b are constants.

According to MADGWICK—OVINGTON (1959) this relationship can best be expressed with an exponential equation (whose curve is asymptotic to both axes). ATTIWILL (1966) suggests a power function in addition to the exponential equation.

It is obvious that the amount of precipitation and the concentration of the elements are in inverse ratio to one another. We have assumed that in the present case the relation between X and Y is: $Y = cX^{-b}$ (where the logarithm of Y is in linear correlation with that of X). By making a logarithmic equation of this we obtain the equation $\log Y = \log c - b \log X$. To determine the unknown coefficients ($\log c = a$ or b) in this equation, we carried out a linear regression by computer on the basis of the equation $\log Y = a - b \log X$, where Y = ion concentration in mg/litre, X = amount of precipitation in mm. We applied the above correlations (n = 10) to five elements (K, Na, Ca, Mg, SO_4—S) in relation to the atmospheric precipitation and the throughfall water in the four combinations; the results are summarized in Table 4.

It can be observed that with the increase in the amount of water the ion concentration in the atmospheric precipitation decreases in the following order: SO_4—S > Ca > Na > Mg > K; furthermore the changed concentration of potassium does not show any close connection with changes in the quantity of precipitation. A similar observation was made by MADGWICK—OVINGTON (1959).

In both the combinations of tree + shrub examined the ion concentration of the canopy throughfall decreases with the increasing water quantity in the following order: Mg > Ca > SO_4—S > K > Na; however, this functionality does not hold true for Na. It can also be clearly seen that the extent of the decrease is similar for both combinations, and for each element (except Na).

The concentration of elements in rainwater passing through the foliage of *Quercus cerris* decreases as the precipitation increases in the following order: Mg > Ca > K > SO_4—S > Na, which is almost in agreement with the order obtained for tree + shrub combinations (in water falling through the foliage of turkey oak the concentration of potassium ion decreases to a slightly greater extent than that of the SO_4-ion, but the difference is not significant).

Table 4

Relationship between the amount of precipitation X (mm) and its element concentration Y (ppm). lg Y = a − b lg X, n = 10

Atmospheric precipitation	a	b	r	Significance of "r"
K	1.08	0.30	−0.489	n. s.
Na	0.62	0.30	−0.797	P = 1%
Ca	2.04	0.39	−0.847	P = 1%
Mg	1.13	0.40	−0.710	P = 5%
SO_4−S	2.45	0.47	−0.892	P = 0.1%
Throughfall in *Quercus petraea* + *Cornus mas*				
K	0.82	0.28	−0.758	P = 2%
Na	1.31	0.13	−0.240	n. s.
Ca	1.42	0.32	−0.663	P = 5%
Mg	2.20	0.35	−0.672	P = 5%
SO_4−S	2.27	0.30	−0.636	P = 5%
Throughfall in *Quercus petraea* + *Acer campestre*				
K	0.84	0.29	−0.814	P = 1%
Na	1.48	0.16	−0.295	n. s.
Ca	1.59	0.38	−0.686	P = 5%
Mg	2.50	0.42	−0.843	P = 1%
SO_4−S	2.30	0.31	−0.731	P = 2%
Throughfall in *Quercus cerris*				
K	0.70	0.24	−0.597	P = 10%
Na	0.82	0.03	−0.069	n. s.
Ca	1.24	0.32	−0.694	P = 5%
Mg	2.36	0.42	−0.851	P = 1%
SO_4−S	1.82	0.20	−0.740	P = 2%
Throughfall in *Quercus petraea*				
K	0.31	0.14	−0.545	n. s.
Na	1.40	0.18	−0.438	n. s.
Ca	0.54	0.10	−0.254	n. s.
Mg	1.24	0.12	−0.286	n. s.
SO_4−S	1.59	0.14	−0.554	P = 10%

According to our calculations the relationship between the amount of water passing through the foliage of *Quercus petraea* and its ion concentration cannot be expressed by the equation $\log Y = a - b \log X$. The pairs of data were also run according to the equation $\log Y = a - bX$, but again without any result. Since our investigations have been continued in 1975, the additional data should increase the likelihood of our finding more suitable functionalities. It should be noted that we do not consider that the correlations obtained are applicable to all cases.

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BIOPOLYMER-METAL COMPLEX SYSTEMS. I

EXPERIMENTS FOR THE PREPARATION OF HIGH PURITY PEAT HUMIC SUBSTANCES AND THEIR METAL COMPLEXES

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Metal-free pure peat humic acids were prepared by extraction with diluted aqueous sodium hydroxide and/or sodium pyrophosphate and a combined application of EDTA and anion and cation exchange resins at room temperature. The removal of proteins, polysaccharides and phenol-carboxylic acid type compounds was performed by boiling with conc. hydrochloric acid. A system of low molecular weight fermentation humic acid and hymatomelanic acid was obtained by the microbiological method. The fulvic acids obtained by the modified method of Chalupa–Rochus were freed from metal ions by precipitation in the form of copper fulvates and subsequent treatment with ammonium sulphide. Metal humates and fulvates were obtained in the highest purity by the reaction of pure humic substances with carboxylic acid type resins saturated with metal ions. The preparation of high purity humic substances and metal humates allowed the determination of the physical and chemical properties of the fractions and also facilitated physiological experiments.

Introduction

The metal complexes of biopolymers (e.g. neutral, acidic and mucopolysaccharides, polypeptides, proteins, nucleic and humic acids) as biologically active agents have come to the foreground of scientific research owing to their great practical importance.

Humic substances, which are the main components of moors, peats, lignites, brown coals and soils, are among the most widespread naturally occurring biopolymers. Soil humic substances and their metal complexes, as well as clay mineral–humic acid systems bound by metal ions and hydrogen bridges have an important role in the dynamics and fertility of soils. Microelements essential for plants occur in humic substances mainly in the form of covalent chelate complexes, while in clay minerals they are found in ionic bonds (FEKETE *et al.* 1967, KONONOWA 1958, SCHEFFER—ULRICH 1960, SCHNITZER—KHAN 1972).

Intensive research has been conducted in the field of humic substances since the investigations of Berzelius. Due to the great variety, complexity and heterogeneity of substances grouped under this term and to the various methods of their extraction and impurities, however, often no satisfactory answer could be found to the most fundamental questions.

We wished to develop a reproducible method for the preparation of high purity humic substances in a well defined, uniform, practically homogeneous state. Our aim was to study the physical and chemical properties of these substances in order to obtain products suitable for further research in the field of pedology, plant and animal physiology. For this purpose, good quality, nearly homogeneous peat humic acids were isolated from lowland peat obtained from Úsztatómajor near Keszthely in Hungary (LAKATOS *et al.* 1972, MEISEL *et al.* 1971, SIPOS *et al.* 1972, VINKLER *et al.* 1971).

Materials and Methods

Lowland peat (Úsztatómajor, Keszthely) is a weak basic substance composed mainly of calcium humate, and a mixture of clay minerals, lime-mud, shells and sands. The ash content of the air-dry peat was found to be 28—43%, while organic materials calculated from the carbon content were approx. 30—70%; H 3—4%, N 2%, and total protein content 12.5%. The ash was analysed by emission spectrophotography (L. Vecsernyés, TÁKI, Budapest, 1970) with the following results. Main components: Ca, Al, Si, Fe, Mg (10%); positively detectable: Na and B (1—10%); detectable: Ba, Li, Ti, Mn, Cu, Ni and K (1/10%); detectable only in trace amounts: Pb (10^{-5}%), Mo (10^{-6}%), Be and Zn (10^{-6}%).

I. Humic substances

1. Extraction

Several methods of extraction from soil, lignite, peat and brown coal have been used (SCHNITZER—KHAN 1972) to obtain quantitative amounts of humic, hymatomelanic and fulvic acids in a relatively "native" form. As humic acids are weak acidic substances, they can be obtained in nearly quantitative amounts only with strong basic extractions, such as alkaline hydroxides, phosphates and carbonates. The decomposition and removal of most contaminants, e.g. bitumens, waxes, resins, fats, phospholipoids and carbohydrates (FISCHER 1967) is the other great advantage of the use of strong basic reagents, e.g. sodium hydroxide. The disadvantage of the method is that the strong basic extractants result in a certain degree of degradation as a function of concentration and temperature. This degradation is supported by determination of the molecular weight, i.e. the particle weight in daltons (see Biopolymer–Metal Complex Systems, Part II). It seemed feasible, therefore, to carry out extractions at room temperature in a dilute solution (0.1 mole).

Humic acids extracted with sodium hydroxide will be henceforth referred to as I-humic acids owing to their high protein content, while those extracted with sodium pyrophosphate, with higher ash and lower protein content, will be called II-humic acids. Humic acids treated with ammonium hydroxide will be designated as III- or ammonhumic acids (NEMEE—VOPENKA 1971) for partial incorporation of ammonia and, finally, those extracted with nitric acid as IV- or nitrohumic acids (SMITH—HOWARD 1935), due to their nitro group content.

For the extraction of raw humic acids, 1600 or 1300 g air-dry peat obtained from Úsztatómajor, Keszthely was filled with 0.5% sodium hydroxide (or 5 dm^3 of 0.1 mole sodium pyrophosphate) to give approx. 8 dm^3. The suspension was stirred for 5 min/hr for a period of 8 hours and then allowed to stand overnight for sedimentation. The brown alkaline solution was decanted from the non-diluted peat mud, then centrifuged and filtered through glass wool. The procedure was repeated four (or two) times. The peat was filled up four times (or twice) to 8 dm^3 with fresh 0.5% sodium hydroxide (or 5 dm^3 sodium pyrophosphate, 0.1 *M*). After dilution performed as above, the alkaline filtrate was stirred and adjusted with 2 *N* hydrochloric acid to pH = 8 or pH = 7), then allowed to sediment for 1—2 days. The solution was separated from the deposited grey humic acid by centrifugation and subsequent decantation. The solution was then acidified with 2 *N* hydrochloric solution to pH = 1 and allowed to sediment for 1—2 days. The precipitate was separated by centrifugation and supernatant was used for the preparation of fulvic acid. After being dried at 60°C, the precipitate was ground, washed with 0.1 *M* hydrochloric acid, centrifuged and dried again. This washing procedure was carried out three times.

The raw humic acids obtained from peat and soil contain, in addition to the polynuclear heteroaromatic "nucleus" and functional groups, several other contaminations (CHESHIRE *et al.* 1967). The removal of these contaminations is a difficult task. Hydrolysis with concentrated hydrochloric acid (6N) or mineral acids at 105°C for several hours (48 or 72 hr) may lead to the removal of organic contamination, but "acid boiled" or hydrolysed humic acid suffers degradation, which involves a decrease in molecular weight.

Humic acids of lower molecular weight may be obtained from raw brown humic acids by microbiological degradation e.g. by means of *Mycobacterium citreum* (GORDIENKO 1972, SMALIN 1971) or a mold culture (BURGES—LATTER 1960). The mold culture (mainly *Aspergillus* type with *Penicillium*, *Pseudomonas* as well as *Arthrobacter* and *Actinomyces*) developed on raw brown II-humic acid in 1 month. The brown humic acid has been enzymatically decomposed into two components, a low mol. wt. humic acid and hymatomelanic acid. The low nitrogen content (2.55%) and average molecular weight (1100 daltons) suggest that the product is no fungus humic acid. In order to distinguish the main component with higher mol. wt. (70%) from brown humic acids extracted with sodium pyrophosphate, the former will be referred to as fermentation humic acid and the lower molecular weight component (30%) as fermentation hymatomelanic acid.

Hymatomelanic acids can be extracted from raw brown humic acids with polar organic solvents. Raw brown humic acids extracted from lowland peat (Úsztatómajor, Keszthely) with 96% ethyl alcohol yielded a light brown, so-called "extracted hymatomelanic acid" (1%).

Fulvic acids were extracted by a modified version of the Chalupa—Rochus method (CHALUPA 1965, ROCHUS 1969).

Raw brown humic acids obtained by alkaline extraction from 3000 g air-dry peat were separated with 2 *N* sulphuric acid. A solution of 0.5 *M* aluminium sulphate was added to raw fulvic acid (approx. 10 dm^3; pH = 1), and the mixture was neutralized by gradual addition of concentrated sodium hydroxide with constant stirring. The fulvic acid was bound quantitatively by the precipitating aluminium hydroxide. The yellowish-white precipitate was allowed to stand for 10—12 hours, then separated by centrifugation and washed with distilled water until the sulphate reaction had ceased. Then the precipitate was dissolved in 2 *N* sulphuric acid (approx. 4 dm^3). 15—20% vol. n-butyl alcohol was layered above the aqueous solution and the bulk of the fulvic acids was shaken into the n-butyl alcohol phase.

This shaking procedure (with 9—10% vol. n-butyl alcohol) was repeated several times until the acidic aqueous phase became colourless or light yellow. The n-butyl alcohol phase saturated with aqueous sulphuric acid was neutralized with a barium hydroxide solution, the precipitating barium sulphate was filtered or centrifuged and the solute was evaporated. The amount of raw fulvic acid obtained was approx. 6 g, corresponding to a yield of 0.2%.

Table 1 shows the ultimate analytical data and yield of raw humic, hymatomelanic and fulvic acids.

2. Purification

Due to their high ash content and metal contaminations, all raw materials had to be purified. Several purification methods, namely dialysis (GONZALES—HUBERT 1972, POSPISIL 1971, RASHID 1971), electrodialysis (BURGES 1960, DROZD 1971), fractioned precipitation (KUMADA—KAWAMURA 1968, KYUMA 1964), ion exchange (EVANS—RUSSELL 1959, GAWRONSKI—GLINSKI 1969, HORI—OKUDA 1961, MALIWA—KHAGAROT 1966, RASHID—KING 1969, BREMNER—HO 1962, DORMAAR 1972, SAPEK 1971, MARTIN—REEVE 1958, WRIGHT *et al.* 1958, YUAN 1964), chelate resin techniques (POSNER 1966) and the complexing method (MÜCKE—OBENAUS 1961, OBENAUS—MÜCKE 1963, ZIECHMANN 1964, KLÖCKING 1967, KLÖCKING—MÜCKE 1969, MÜCKE—KLÖCKING 1966, MARTIN—REEVE 1955), have been used, however, with unsatisfactory results.

The aqueous solution of ethylene diamine tetraacetate (EDTA; 4%, pH = 7) was irst applied by DEUEL *et al.* (DUBACH 1963, DUBACH 1964, DUBACH *et al.* 1961, DUBACH—MEHTA 1963) for the extraction of humic and fulvic acids from soils. These authors obtained a product with low ash content only in the case of Podzols. The extraction, however, required relatively large amounts of EDTA, which considerably increased the expenses involved. The application of EDTA for the extraction of lowland peat (Keszthely) by the use of sodium hydroxide yielded raw humic acids with 8.3, 5.9, 5.7 and 2% ash content.

A combined method of complexing with an excess amount of EDTA anion and treatment with anion and cation exchange resins proved to be the most suitable procedure.

A 1—2% solution (min. 0.5% and max. 5%; pH = 5—6) of raw brown humic acids (approx. 600 g) was prepared with 0.5% sodium hydroxide or 0.1 *M* sodium pyrophosphate. This solution was mixed with an excess amount of 0.1 *M* EDTA. We calculated and used a

Table 1

Ultimate analytical data of raw peat humic and fulvic acids

Sample	C	H	N	S	Cl*	O	Ash	Yield
	%							
Brown I-humic acid 1	40.9	5.06	2.82	1.8	2.1	35.2	12.1	3.0
Brown I-humic acid 2	44.6	5.61	3.0	1.7	1.6	37.4	6.1	3.0
Brown I-humic acid 3	41.7	4.66	4.8	1.9	2.1	37.4	7.4	4.3
Brown I-humic acid 4	38.3	4.9	2.9	1.5	4.5	35.3	12.6	4.0
Brown I-humic acid 5	38.1	5.6	2.8	1.7	1.6	43.4	6.8	4.6
Brown I-humic acid 6	44.0	4.8	3.2	tr.	1.6	37.2	9.2	3.2
Brown I-humic acid 7	41.0	4.7	2.2	1.7	2.9	35.9	11.6	6.0**
Brown II-humic acid 1	36.0	6.81	2.45	1.7	2.0	28.6	22 5	18.2
Brown II-humic acid 2	37.1	5.19	1.75	1.6	1.6	34.0	18.6	10.8
Brown II-humic acid 3	32.5	3.41	2.2	1.5	1.9	35.0	23.5	21.0
Brown II-humic acid 4	39.1	3.96	2.15	tr.	tr.	37.0	17.71	10.01
Brown II-humic acid 5	34.6	5.1	2.1	2.0	3.0	31.3	21.8	16.0
Gray I-humic acid	32.2	4.3	3.2	—	—	31.2	31.1	0.05
Gray II-humic acid	38.7	6.2	2.5	—	—	29.2	22.4	0.05
Fulvic acid A_o-level	34.9	5.68	tr.***	2.0	tr.	27.0	30.28	0.1
Fulvic acid B_h-level	41.4	5.14	tr.	1.9	tr.	30.0	21.0	0.2

* Cl-ion is a contaminant
** Under continuous stirring for 24 hr
*** tr = traces

treble amount of excess EDTA related to the total ash content, which, for the sake of simplicity, was considered to be pure aluminium oxide. The solution was intensively stirred for 48 hours to allow the reaction and complexing of metal ion contaminations with EDTA. The solution was passed through a column of strong basic anion exchange resin in hydroxide cycle (Amberlite IRA-400, ∅: 50 mm, height: 560 mm) at a rate of 500 cm^3/hr. The excess of EDTA anions and their metal complexes with negative charges were exchanged for hydroxyl ions. This column was directly attached to a strong acidic cation exchange resin in hydrogen cycle (Amberlite IR-120, ∅: 50 mm, height: 560 mm) and the solution was passed through it at the same rate as above. Then the non-complexed alkaline cations exchanged for hydrogen ions and at pH = 2.7 a pure metal-free humic acid solution could be collected and finally freeze-dried.

Analytical results of pure samples are depicted in Table 2, where the numbers indicate raw humic acids and those marked with a prime show purified samples.

Purification with ion exchange resins before and after treatment with EDTA produced brown humic acids with less than 1% ash content. Analytical data of these products are listed in the last two lines of Table 2. Emission spectrum analysis data of ash are collected in Table 3.

The relatively high nitrogen content of I-humic acid pointed to the presence of considerable amounts of polypeptides, which could be removed only by means of concentrated hydrochloric acid hydrolysis. These polypeptides cannot be separated by fractioned solution or precipitation at various pH values or in the form of an insoluble precipitate doped by divalent (e.g. calcium) or trivalent metal ions (e.g. iron or aluminium) (LOGINOW 1961). In the case of fractioned precipitation with saturated aqueous sodium sulphate solution,

Table 2

Ultimate analytical data of pure brown humic acids

Raw humic acids	Ash	C	H	N	S	Cl	(O)	Pure sample
	%							
I-humic acid 1	2.0	42.9	4.9	2.9	1.8	tr.	45.5	I-humic acid 1′
I-humic acid 2	3.7	42.6	4.1	3.0	1.7	tr.	44.9	I-humic acid 2′
I-humic acid 3	1.5	43.8	4.2	4.8	2.1	tr.	43.6	I-humic acid 3′
I-humic acid 1+2+3	1.1	49.4	4.8	2.4	2.1	tr.	40.2	I-humic acid 6′
I-humic acid 4	1.2	50.0	4.0	2.9	1.5	tr.	40.4	I-humic acid 4′
I-humic acid 4+5	1.8	46.8	4.8	3.2	1.7	tr.	44.5	I-humic acid 5′
I-humic acid 6+7	3.4	48.0	4.8	3.3	1.5	tr.	39.0	I-humic acid 7′
I-humic acid 1′	0.9	54.4	5.1	2.0	1.5	tr.	36.0	I-humic acid 1″
II-humic acid 2′	0.8	47.5	4.0	1.8	1.6	tr.	45.1	II-humic acid 2″

Table 3

Emission analysis data of ash

Ash	Fulvic acid	I-humic acid 1″	II-humic acid 2″
Ash	1.43	0.9	0.8
Fe	$1 \cdot 10^{-6}$	$5 \cdot 10^{-3}$	$1 \cdot 10^{-3}$
Cu	$2 \cdot 10^{-3}$	$1 \cdot 10^{-3}$	$1 \cdot 10^{-3}$
Mn	$1 \cdot 10^{-3}$	10^{-3}	10^{-3}
Co	$1 \cdot 10^{-3}$	10^{-6}	10^{-6}
Ca, Mg, Al	$\sim 10^{-1}$	$\sim 10^{-1}$	$\sim 10^{-1}$

the readily precipitating fractions were found to contain somewhat more polypeptides, not sufficient, however, for quantitative separation.

The air-dry samples were hydrolysed with 6 *N* hydrochloric acid at 105°C in a nitrogen atmosphere for 48 hours, then dried *in vacuo* at 70°C in the presence of phosphoric pentoxide, and deacidified with solid potassium hydroxide. The deacidified dry residue was dissolved in 0.01 *N* hydrochloric acid containing 0.2 *M* sodium chloride (5 cm^3) and, after filtration, was analysed on the column of an amino acid analyser (Beckman Unichrom) by a three-buffer method. The results afforded the amino acid composition data depicted in Table 4.

Naturally, such digestion involves, in addition to the hydrolysis of polypeptides, other significant changes, e.g. 20% loss of weight, 50% decrease in methoxy groups and nearly 100% decrease in the number of quinone groups. Owing to the great decrease in overall weight, the ash content percentage increases while the amount of ash metal oxides decreases. Analytical data of the starting materials and products obtained are listed in Table 5.

The Molish reaction performed with hydrolysed humic acid as well as the negative result of the iron (III) chloride test suggests that the hydrolysed product is practically free from carbohydrates and phenol-carbonic acid type contaminations.

For the preparation of metal-free fulvic acids, raw fulvic acids were precipitated with a solution of 0.1 *M* copper (II) acetate in the form of copper (II) fulvate. The precipitate

Table 4

Amino acid composition (%) of peat and peat humic acid and feeds

Amino acids	Peat (Keszthely)	I-humic acid	III-humic acid	Torula yeast	Mixed meat flour
Lys.	4.5	6.0	4.5	7.2	4.0
His.	2.0	1.7	2.1	2.5	2.0
Arg.	3.3	4.6	5.8	4.2	5.3
Asp.	16.9	17.2	16.0	—	—
Thr.	7.1	6.0	2.4	4.8	4.4
Ser.	5.2	4.6	1.6	—	—
Glu.	13.1	13.5	13.4	10.3	10.0
Pro.	3.9	4.2	7.6	—	—
Gly.	10.4	9.8	11.8	3.6	16.1
Ala.	8.4	5.6	7.1	—	—
Val.	7.8	7.4	6.3	3.9	6.2
Met.	1.9	1.8	tr.*	0.8	1.3
Ile.	5.2	6.0	6.8	3.6	3.9
Leu.	7.1	7.9	10.2	7.2	8.4
Tyr.	1.3	tr.*	tr.*	—	—
Phe	3.9	4.6	4.7	4.8	5.0
Total N	2.0	4.8	3.5	7.5	3.5
α-N	1.4	4.7	0.6	—	—
Protein	8.75	30	3.8	47.2	21.5

* Decomposing during alkaline extraction

Table 5

Ultimate analytical data of I-humic acid prior to and after hydrolysis

Sample	C	H	N	S	Cl	O	Ash	OCH_3	Quinone	Total acid	—COOH
	%						mequ/g				
I-humic acid 7′	48.0	4.8	3.3	1.5	tr.	39.0	3.4	2.5	1.9	4.2	2.9
Hydrolysed humic acid	48.8	4.5	1.8	1.9	1.6	36.0	4.6	1.4	0.0	8.4	4.8

was dissolved in aqueous ammonium hydroxide, copper (II) and the contaminating metal ions were precipitated with ammonium sulphide. The solution was acidified at pH = 1, the precipitated sulphur was filtered and after the extraction of fulvic acid with n-butyl alcohol, the solvent was distilled. The analytical data of the product point to the formation of pure fulvic acids with low ash and metal contents (Table 6).

Table 6

Ultimate analytical data of pure fermentation humic, hymatomelanic and fulvic acids

Sample	Analytical data, %						
	Ash colour	C	H	Cl	S	N	(O)
Fermentation humic and hymatomelanic acids	1.22 light yellow	43.5	4.4	0.9	0.5	2.5	(47.0)
Extracted hymatomelanic acid	1.97 light brown	52.2	5.8	tr.	tr.	2.1	(40.0)
Fulvic acid	1.43 white	38.0	5.6	tr.	3.0	tr.	(52.0)

II. Metal–humic compounds

The preparation of humic, hymatomelanic and fulvic acid compounds, salts and/or complexes with metal ions was carried out by four methods.

1. Metal humates, hymatomelanates and fulvates were prepared by neutralization (KONONOWA 1958, SCHEFFER—ULRICH 1960, SCHNITZER—KHAN 1972). Pure metal-free humic acid obtained from the cation exchange resin in hydrogen cycle was adjusted to pH = 8 with the aqueous solution of the corresponding alkaline hydroxide. The solution obtained was carefully concentrated, then freeze-dried.

2. Divalent alkaline earth metal, 3d-transition metal and aluminium humates were obtained by an exchange reaction (KONONOWA 1958, SCHEFFER—ULRICH 1960, SCHNITZER—KHAN 1972).

The aqueous solution of sodium humate (100 cm^3, 5%) was added to an approx. tenfold amount (200 cm^3) of 1 *M* aqueous solution of metal salt (sulphate, chloride or acetate). Prior to the above reaction, however, 200 cm^3 of dilute sodium humate (0.025%) was added to the metal salt under intensive agitation to form germs. After 10 sec the 5% sodium humate solution was diluted threefold and added dropwise to the inoculated metal salt solution under intensive stirring. The pH value of the initial sodium humate was adjusted to a lower value than that of the precipitation of metal hydroxide, consequently, the pH value of the aqueous coarse suspension was also lower. The system was further agitated for approx. 1 hour and the coarse suspension was allowed to stand in a sealed vessel at room temperature for one week. The precipitate was then centrifuged, washed with cold distilled water and dried to constant weight in a phosphoric pentoxide exsiccator.

In favour of the second method is its simplicity, while its disadvantage is that, depending on the pH value, the metal humate contains hydrogen ions, since all the above-mentioned pH values for precipitation are below 7. On the other hand, it also contains the side ion of the solution, in this case, sodium ion. Naturally, the higher the pH value of precipitation, the lower is the number of unsubstituted hydrogen ions and the higher the amount of side ions (e.g. sodium ion). The preparation of metal humates free from side ions and other additional ions can be carried out by method 3 (SAPEK 1970a, 1970b, 1971).

3. The method of ion exchange resins is suitable for the preparation of metal humic systems. After saturation with metal ions the carboxyl type resin is allowed to react in a static or dynamic system with a purified humic acid solution according to the following relationship:

$$(R\text{–}COO)_2Fe + 2Hu \rightleftharpoons Feu_2 + 2R\text{–}COOH$$

where Hu stands for humic acid and u for the humate anion.

The reaction is carried out as follows. Approx. 10 cm^3 of a weak acidic carboxylic type cation exchange resin in H^+ form (Duolit CS 101 or Amberlite IRC 50) is saturated with a 0.1 *M* aqueous solution of metal salt in a dynamic system until the hydrogen ions are completely exchanged. The resin is then washed and suspended in a small amount of distilled water. To this suspension, a 1% solution of double ion-exchanged pure II-humic acid (100 cm^3, at pH = 2.7) obtained from a strong acidic cation exchange resin in hydrogen cycle (Amberlite IR-120) is added dropwise under intensive agitation. This static system is agitated

for 24 hours, then the resin is separated from the metal humate suspension by means of a glass filter G 1. After centrifugation, the solution containing the suspension is evaporated and freeze-dried. A dynamic system can also be applied, in which the humic acid solution is allowed to pass gradually through the resin column saturated with metal ions.

4. The reaction between *in statu nascendi* formed metal ions and humic substances is especially feasible when the metal ion forms a slowly reacting inert aquo complex, e.g. in the case of chromium(III) ion. The chromium(III)-hexaquo complex ion is practically unreactive towards humic acid. The reaction carried out at room temperature under constant agitation for one week produced bonds detectable by ESR only in trace amounts (see Biopolymer metal complex systems IV). On the other hand, the reduction of dichromate or chromate ions into chromium(III) in strong acidic medium in the presence of humic acids at room temperature can be carried out with a strong reducing agent, e.g. hydrazine, only in the case of simultaneous quantitative bonding of the chromium(III) ion to the humic acids. This quantitative bonding occurs only when the humic acid solution is previously added to an excess amount of acidic dichromate solution, followed after the elapse of 1 min by the addition of an excess amount of hydrazine sulphate solution. Similarly to the reaction with chromium(III) salts, the acidic dichromate solution added to a cold or warm mixture of humic acid and hydrazine sulphate resulted in trace amounts of bonded chromium(III) ions.

The solution of 0.1 g humic acid in 3 cm^3 conc. alkaline hydroxide was acidified to pH = 6 with sulphuric acid. After the addition of 3 cm^3 0.1 *M* potassium dichromate solution, 1.5 cm^3 1 *N* sulphuric acid was added and the system was vigorously shaken for 1 min. The aqueous solution of 5 cm^3 0.1 *M* hydrazine sulphate was added to the mixture, which was kept at room temperature overnight (pH = 3), then centrifuged, washed and dried.

Analytical data of some metal humates are depicted in Table 7.

Table 7

Ultimate analytical data of metal humates

Sample	Metal	C	H	N	S	Cl	(O)
	%						
Iron I-humate	12.1	26.7	4.6	3.2	1.6	0.2	52
Iron hyd. humate	11.8	36.7	3.4	1.1	1.1	0.1	46
Iron II-humate	7.0	35.1	4.0	2.1	2.9	0.7	48
Iron III-humate	13.5	39.7	3.0	2.5	2.6	0.2	37.5
Copper I-humate	17.1	18.2	3.7	3.2	2.0	0.3	35.5
Copper hyd. humate	14.3	39.3	3.2	1.2	1.9	0.2	40
Copper II-humate	11.7	36.4	3.6	1.7	1.4	0.3	45
Copper III-humate	13.1	38.9	2.8	2.2	1.6	0.8	40
Cobalt II-humate	4.7	35.2	3.9	1.8	0.9	2.2	51
Cobalt III-humate	8.3	39.0	3.5	2.4	1.3	3.4	42

Results

Based on our investigations with good quality peat available at Úsztatómajor (near Keszthely, Hungary) pure brown humic acids were obtained by a procedure applicable also on an industrial scale. Alkaline extraction with 0.5% aqueous sodium hydroxide allowed the removal of several contaminations, e.g. bitumens, polysaccharides, hemicellulose, without significant

degradation. The yield could be increased by continuous intensive agitation and by increasing the concentration of alkali to an optimum amount of 2%. In the latter case, however, a certain degree of degradation must be taken into account.

All extractions were performed at room temperature in order to avoid decarboxylation at higher temperatures (the average decrease in carboxyl content at the boiling point was 1 mequ./g). Airing of the alkaline solution or the application of other oxidizing agents, e.g. an aqueous solution of hydrogen peroxide, did not increase the yield considerably.

Raw brown humic acids were freed from their metal contaminations by a combined method of complexing with an excess amount of ethylene diamine tetraacetate anion and treatment with anion and cation exchange resins. The ash and metal content of the purified brown, I- and II-humic acids was sufficiently low (Tables 2 and 3) to allow physical and chemical investigations as well as physiological experiments.

A comparison of the amino acid composition of peat and humic acid proteins obtained from Keszthely with that of other protein sources (Table 4) showed that lowland peats and humic acids actually contain the same species, a transition between bacterial and animal proteins, due to their surprisingly high lysine and methionine content. This conclusion is in accordance with the microbiological origin of I-humic acids from soils. The hydrolysis of humic acids with concentrated hydrochloric acid also caused the removal of polysaccharides and phenol-carboxylic acids. Both hydrolysed and II-humic acids contain considerable amounts of unhydrolysed nitrogen, which is, according to data in the literature (BUTLER—LADD 1971, FLAIG 1963, GRISBANE *et al.*, 1972, LADD—GRISBANE 1967, LADD 1968, LADD—BUTLER 1969a, 1969b, 1970, SCHARPENSEEL—KRAUSSE 1962), an integral part of humic substances. These may be in the nucleus in a condensed or heterocyclic bond or, possibly, in a Schiff-base bond (WITTHAUER—KLÖCKING 1971). Humic substances show various degrees of nitrogen content. The smallest amount ($\sim 10^{-1}\%$) can be detected in moor water (fulvic acid), 0.4—6% is found in peats, 1—2% in lignite and brown coal and even more in soils. Humic proteins containing nitrogen in 11—14.8% could be isolated from soils by paper chromatographic methods. Coffee humic acids show 3.5—4.2% N content, while fungus humic acids contain nitrogen in 9%. In general, nitrogen bound to humic substances shows great biological resistance, therefore, obtaining a nitrogen-poor and entirely protein-free humic acid nucleus requires a very radical method, e.g. boiling in concentrated mineral acid, which, owing to protein and ester hydrolysis and scission of the aromatic skeleton of the nucleus, involves an increase in the number of carboxyl groups, and a decrease in the number of methoxy and quinone groups (Table 5). Extraction or treatment with ammonia leads to an increase in the

nitrogen content, owing to the reaction of ammonium with certain functional groups of humic acids, e.g. with the oxo-group. The low nitrogen content of fermentation humic acid also facilitated the distinction of this humic acid from fungus humic acids.

The metal content of metal humates generally increases with the increase in the pH values, owing to the greater dissociation of acidic groups. The amount of metal is generally smaller than the total acidity, since the rest of the capacity is saturated by non-substituted hydrogen and side ions and possible metal contaminations. Humic metal bonds may be ionic or covalent chelate-type, identified by IR and ESR measurements, Mössbauer spectroscopy and stability investigations (see Biopolymer–metal complex systems Parts III and IV, VINKLER *et al.*, 1975).

In studying the effect of EDTA on the hydrazine and chromium(VI) reaction, BECK—DURHAM (1971) presumed the formation of a transition complex: ternary hydrazine-(chromium(VI))$_2$-EDTA. Owing to similar functional groups, the formation of a ternary hydrazine-(chromium(VI))$_2$-humic acid ternary complex may be assumed as the first step of the reaction also in the case of humic acids. On completion of the reaction, there is a possibility of further bonding of the functional groups (e.g. carboxylic, phenolic OH) in contrast to the chromium(III)-hexaquo ion which is co-ordinatively well screened.

Ultimate analysis and functional group determinations of the humic acids were carried out by classical methods of micro and semi-micro analysis (BOROMISSZA—VARGA 1972). Metal humates and fulvates were dissolved by Schulek's method of digestion with hydrogen peroxide and concentrated sulphuric acid and the metal contents were determined by complexometry (SAJÓ 1973).

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VARIA

INFLUENCE OF CERTAIN OIL CAKES ON THE GERMINATION PROCESS OF PHASEOLUS AUREUS SEEDS

The addition of organic matter to the soil has a profound effect on many biological, physical and chemical processes in the soil. Oilcakes too, as organic sources of nitrogen, have been proved to exercise a profound effect not only in promoting the vigour and growth of host plants, but also in the control of plant parasitic nematodes (SAYRE 1971), by providing the hosts with some resistance to the attack of phytonematodes (VAN DER LAAN 1956). Surprisingly enough, the effect of these beneficial sources of nitrogen on the germination process of seeds in general has not been studied in greater detail (JAMAL 1974). The present study was undertaken in order to fill this gap.

The seeds of *Phaseolus aureus* Roxb. var. S8 were selected to test the effect of some commonly used oilcakes, viz. castor (*Ricinus communis* L.), groundnut (*Arachis hypogaea* L.), mustard (*Brassica nigra* L. Koch.) and neem (*Azadirachta indica* Juss.). The experiment was conducted in 15 cm pots containing oilcake-treated garden soil. A uniform amount of oilcake with respect to their nitrogen content (1 g of nitrogen per kg of soil) was used in all cases. The pots were watered daily. After a lapse of 7 days the surface-sterilized viable seeds were sown in the pots at equidepth at the rate of 1000 per treatment. Seeds sown in unamended soil served as control. The pots were kept on glasshouse benches (temperature 28 ± 4°C). The percentage of seed germination was noted for 6 days at an interval of 24 hours each. The results were statistically analysed and summarized in Table 1.

No seed germinated under any of the treatments up to 24 hours. In a period of 2 days, the germination was stimulated in the neem cake amended soil by 28%. On the other hand, it was suppressed by 88, 85 and 20% in soil amended with castor, groundnut and mustard cakes, respectively. By the third day, the neem cake soil had promoted the germination

Table 1

The influence of castor, groundnut, mustard and neem cakes on the seed germination of Phaseolus aureus Roxb

Treatments	*Germination after									
	48 hr		72 hr		96 hr		120 hr		144 hr	
	A	B	A	B	A	B	A	B	A	B
Castor	66	−88.3	310	−62.7	565	−37.8	665	−31.0	876	−10.6
Groundnut	88	−84.5	288	−66.6	499	−45.1	599	−37.9	821	−16.2
Mustard	455	−19.6	699	−16.0	965	+ 6.2	965	+ 0.1	980	0.0
Neem	722	+27.6	877	+ 5.4	954	+ 5.0	960	− 0.4	979	− 0.1
Unamended	566	0.0	832	0.0	909	0.0	964	0.0	980	0.0
C. D. 0.05	2.9043		3.0937		2.0625		5.8018		1.7526	
0.01	5.6804		4.5011		3.0007		8.4992		2.5498	

* No germination after 24 hours

A = total number of seeds germinated per 1000 seeds (each reading is a mean of 3 replicates).

B = percentage increase (+) or decrease (−) in germination over control

by about 5%, while the groundnut cake soil had suppressed the process by 67%, castor by 63% and mustard by 16%. The castor and groundnut cakes, as reported earlier (JAMAL 1974), significantly delayed the germination of the tested seeds at the initial stages, as a result of the toxic ingredients released during their decomposition (SAYRE 1971). Although this suppressive effect of the above cakes remained effective even on the sixth day, the degree of suppression became much less. In mustard cake treatment, the process showed a recovery on the fourth day indicating that its apparent inhibitory effect is only transient, not a permanent one. The influence of different oilcakes on the germination process of *Phaseolus aureus*, therefore, appears to be variable, some stimulating, others suppressing it to varying degrees, particularly at the initial stages of the process.

Since the inhibitory effects of the oilcakes tested are only transient and have practically disappeared after 144 hours, and since the delay of 72 hours caused in germination does not seem to have any practical importance under field conditions, their apparent adverse effects on germination may be overlooked and these organic sources of nitrogen may be recommended for field crops like *Phaseolus aureus*, as they have already proved to be very effective both in promoting the vigour of the hosts and in the control of phytonematodes. A similar situation has been reported in the germination of green gram seeds in relation to certain common nematocides (JAMAL—GHOUSE 1974).

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EFFECTS OF ROOT-STOCK AND INTERGRAFTED VARIETY ON CATALASE ACTIVITY IN JONATHAN LEAVES

During the investigations the catalase enzyme activity was regarded as an index of the physiological state, in agreement with TOMBESI (1953), KOZMA (1963), MIHÁLYFI (1965), SADMANOV—NIKOKIRISZ (1972), FRENYÓ—PÁDY (1971, 1972) and other authors. An attempt was made to discover how the catalase activity in the leaves of the Jonathan scion was influenced by its root-stock and interstocks.

The trees examined were planted at the Szigetcsép Experimental Station of the University of Horticulture in Budapest a split-plot random block design at a spacing of 7×4.5 m with 10 replications per combination.

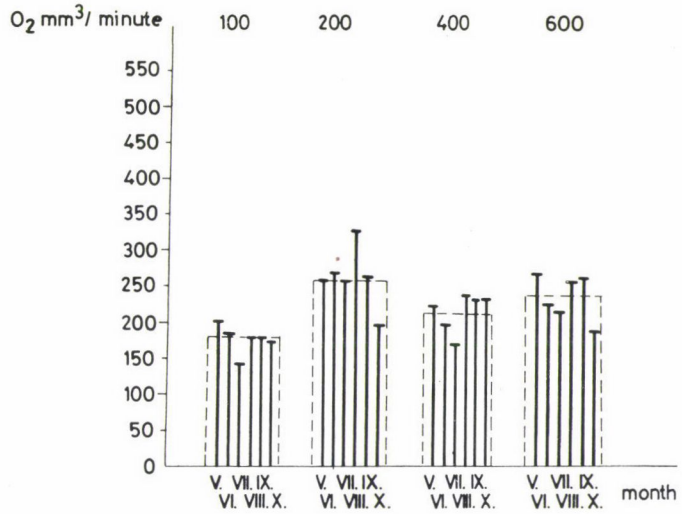

Fig. 1. Catalase enzyme activity values for the varieties (1969—1972). 100 = M.9, 200 = M.4, 400 = *Malus silvestris*, 600 = own-rooted Jonathan

The own-rooted varieties included in the experiment were: M.4, M.9, *Malus silvestris* seedling, Jonathan; scions: M.9/Jonathan, M.4/Jonathan, *Malus silvestris*/Jonathan and variations of these; interstocks: M.9/M.9/Jonathan, M.9/M.4/Jonathan, M.9/*Malus silvestris*/Jonathan, M.4/M.4/Jonathan, M.4/M.9/Jonathan, M.4/*Malus silvestris*/Jonathan, *Malus silvestris*/*Malus silvestris*/Jonathan, *Malus silvestris*/M.9/Jonathan, *Malus silvestris*/M.4/Jonathan.

Foliage samples were taken during the vegetation period from May to mid-October in 1969—1972 twice a month, on a total of 12 occasions a year. Each leaf sampling was carried out between 9 and 11 a.m.

The catalase activity was determined by the gasometric method of FRENYÓ (1962).

In evaluating the catalase enzyme activity the monthly means of the activity values were taken as the basis, whereby the scattering was limited and the changes in the individual values during the vegetation period could be followed more easily.

Physiological differences between the varieties can be characterized by the catalase values shown in Fig. 1.

Own-rooted varieties. There are characteristic differences in catalase enzyme activity between the own-rooted varieties. The activity was most intensive in the leaves of M.4 and least intensive in those of M.9, while the activity in the leaves of *Malus silvestris* seedlings and Jonathan gave intermediate values.

On a monthly average the varieties did not significantly differ in catalase activity during the four years. It is probably a "stochastic" phenomenon, where the varietal differences are concealed by changes caused by the uncontrolled environment, which cannot be studied separately.

The catalase enzyme activity varied from year to year and in the course of the vegetation period, being influenced by meteorological factors, particularly the temperature.

The effect of the root-stock. The values of catalase enzyme activity in the scion are influenced by the root-stock. The trend of catalase enzyme activity in the own-rooted varieties used as root-stocks (Fig. 1) is different from that in the scions (Fig. 2).

In each case the root-stocks were found to increase the catalase enzyme activity in Jonathan leaves compared to that in own-rooted trees.

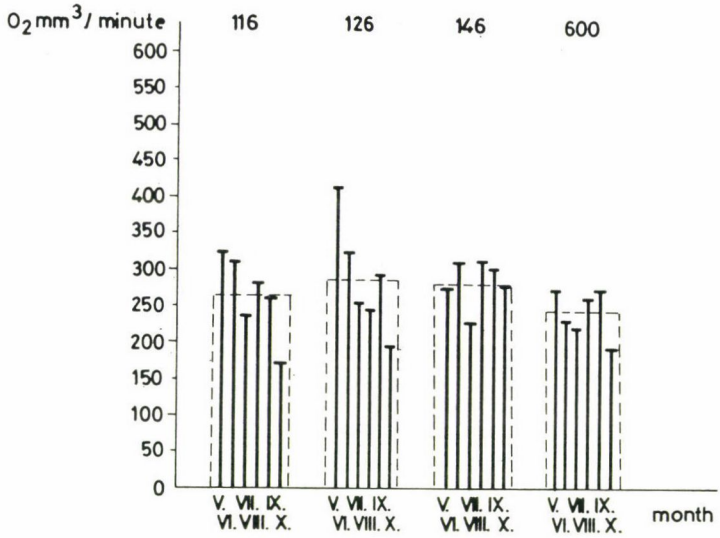

Fig. 2. Catalase enzyme activity values of scions (1969—1972). 160 = M.9/Jonathan, 260 = M.4/Jonathan, 460 = *Malus silvestris*/Jonathan, 600 = own-rooted Jonathan

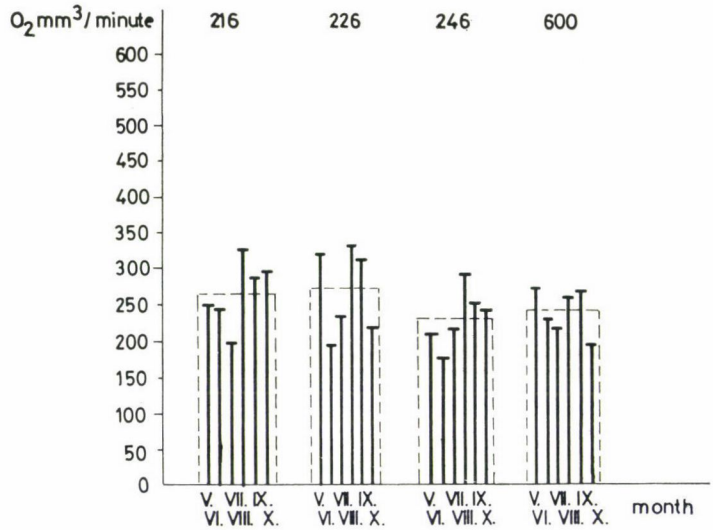

Fig. 3. Changes in the catalase enzyme activity of leaves in graft combination (1969—1972). 116 = M.9/M.9/Jonathan, 126 = M.9/M.4/Jonathan, 146 = M.9/*Malus silvestris*/Jonathan, 600 = own-rooted Jonathan

The effects of interstocks. Interstocks further modify the catalase activity in the leaves of the scion, which is theoretically to be expected due to the increased complexity of the intergrafted tree. No conclusions can be reached, however, on the direction of the change.

The standard deviation is not given in the figures as in addition to chance scattering the data also include the gradient (trend) related to the development. The variants were compared on the basis of the mean value, because the trends of catalase activity do not run parallel throughout the vegetation period.

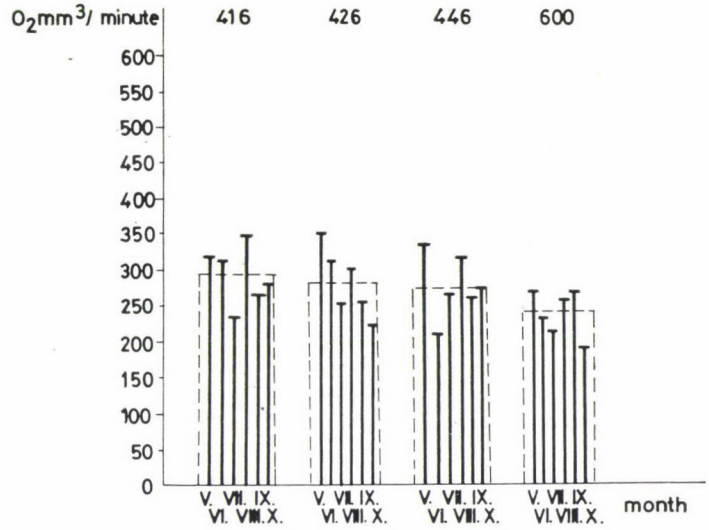

Fig. 4. Changes in the catalase enzyme activity of leaves in graft combinations (1969—1972) 216 = M.4/M.9/Jonathan, 226 = M.4/M.4/Jonathan, 246 = M.4/*Malus silvestris*/Jonathan, 600 = own-rooted Jonathan

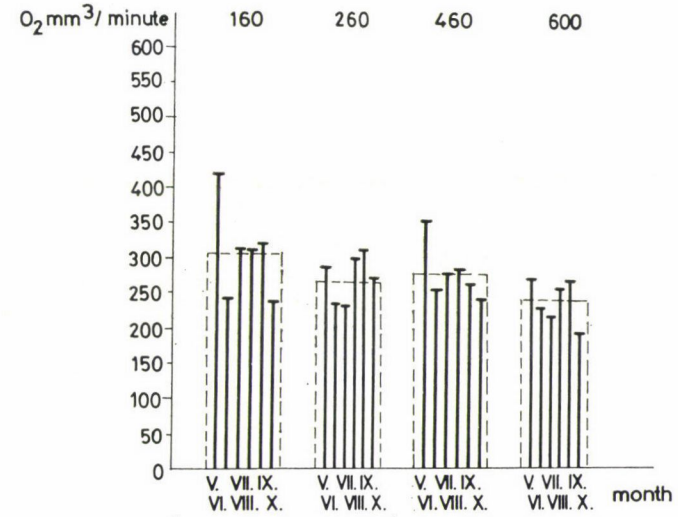

Fig. 5. Changes in the catalase enzyme activity of leaves in graft combinations (1969—1972) 416 = *Malus silvestris*/M.9/Jonathan, 426 = *Malus silvestris*/M.4/Jonathan, 446 = *Malus silvestris*/*M. silvestris*/Jonathan, 600 = own-rooted Jonathan

Figs 3, 4 and 5 show that the interstock did not increase the catalase enzyme activity in the levaes of the scion. On root-stocks M.9 and M.4 the interstocks decreased the catalase enzyme activity in the leaves of the Jonathan scion compared to grafts with the same root-stocks.

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VARIABILITY IN QUANTITATIVE CHARACTERS OF MESTA (HIBISCUS CANNABINUS L.)

Before initiating a plant breeding programme to improve a crop, it is desirable to have a prior knowledge about the magnitude of its genetic variability. The exploitation of the genetic variability of a crop would require a thorough knowledge of the heritabilities and genetic gains of different agronomic characters. Though Mesta is a very well known bast fibre crop in India, the genetic variability of this crop has not been studied so far.

An attempt has been made to elucidate this aspect of Mesta and the results are reported in this paper.

30 Mesta varieties were grown in a randomized block design with 6 replications on the main farm of the Jute Agricultural Research Institute, West Bengal. Each plot had a single row, 30 m long. The distances between rows and within rows were 30 cm and 12 cm, respectively. Ten plants were selected at random from each plot for observation. The following measurements of seven quantitative characters were recorded: (1) plant height, (2) basal diameter, (3) number of nodes, (4) days to flower, (5) stripped green weight, (6) wood weight and (7) fibre weight. The mean value of 10 plants per replication was used for each character in the statistical analysis.

Analysis of variance for each of these characters was computed. The genotypic, phenotypic and environmental variances were estimated from relevant variance components. In the Anova table, the expectation of the varietal mean square (V) may be expressed as $V = \sigma_e^2 + r\,\sigma_g^2$ where $\sigma_e^2 = E =$ the mean square of the expectation of error, i.e. environmental variance pertaining to plot means, $\sigma_g^2 =$ total genetic variance and $r =$ number of replications. Thus $\sigma_g^2 = \dfrac{V-E}{r}$. The phenotypic variance was estimated as $\sigma_{ph}^2 = \sigma_g^2 + \dfrac{\sigma_e^2}{r} = \dfrac{V}{r}$ where $\dfrac{\sigma_e^2}{r} =$ environmental variance of varietal means. From the above estimated variances, the genotypic coefficient of variability (GCV) and the phenotypic coefficient of variability (PCV) were estimated according to the formulae suggested by BURTON (1952) and BURTON—DEVANE (1953). Thus

$$\text{GCV} = \frac{\sqrt{\sigma_g^2}}{\bar{x}} \times 100$$

and

$$PCV = \frac{\sqrt{\sigma^2_{ph}}}{\bar{x}} \times 100$$

where $\bar{x}$ = the mean character value.

Heritability (h^2), in a broad sense, was estimated according to the method given by ALLARD (1960), HANSON *et al.* (1956) and BURTON—DEVANE (1953) as follows:

$$h^2 = \frac{\sigma^2_g}{\sigma^2_{ph}} = \frac{\frac{V - E}{r}}{\frac{V}{r}} = \frac{V - E}{V}$$

The expected genetic advance (GA) was estimated according to the method given by LUSH (1949), ROBINSON *et al.* (1949) and JOHNSON *et al.* (1955) as follows:

$$GA = s \cdot \frac{\sigma^2_g}{\sqrt{\sigma^2_{ph}}}$$

Where $s = 2.06$ for 5% of the population saved. GA was also calculated as the percentage of the mean.

An analysis of covariance was made for every pair of characters studied. The genetic covariance component for a pair of characters was estimated in the same manner as was adopted in the estimation of genetic variance from the analysis of variance indicated earlier. To detect the degree of coinheritance of two characters "a" and "b" together, coheritability estimates (C_{ab}) were calculated according to the formula laid down by NEI (1960). Thus,

$$C_{ab} = \frac{Cov_{gab}}{\sigma_{pha} \cdot \sigma_{phb}}$$

where $\overline{Cov_{gab}}$ = genetic covariance of the characters "a" and b""
σ_{pha} = phenotypic standard deviation of character "a"
σ_{phb} = phenotypic standard deviation of character "b"

Analysis of variance, mean, standard error, critical difference (CD) at the 5% level and range are presented in Table 1. Stripped green weight showed the widest range of variability (85.54—353.73), followed by plant height (230.96—389.76). The least range of variability was observed for the basal diameter (1.09—2.03). Statistical analysis revealed highly significant varietal differences for each character under study. Values of the standard errors show that the mean character values were dependable (Table 1).

The estimated phenotypic and genotypic variances were highest for stripped green weight. Plant height came next in this respect. The genotypic variances for all the characters under study were lower than the phenotypic variances. Such influences were also evident between the two corresponding coefficients of variability. Stripped green weight, wood weight and fibre weight showed a GCV and PCV each of about 30 per cent. For other characters these were about 10 per cent (Table 2).

Though the GCV is a very useful index of the potential advance latent in the population for measuring the range of genetic diversity of any available genetic material in respect of each character, it cannot determine the heritable portion of variation. BURTON (1952) suggested that the GCV together with heritability estimates would give the best picture of the amount of advance to be expected by selection pressure to a population in separating genotypes on the basis of the phenotypic expressions. Days to flower showed the highest

Table 1

Analysis of variance and phenotypic variation for each of the seven agronomic characters of Mesta

Source	d. f.	Characters						
		Plant height (cm)	No. of nodes per plant	Basal diameter (cm)	Days to flower	Stripped green weight (g)	Wood weight (g)	Fibre weight (g)
Blocks	5	4883.6000	344.1400	0.1409	207.0200	10509.4000	397.1420	38.5728
Varieties	29	10124.6200**	719.1586**	0.3641**	2797.8310**	38792.9310**	1526.2544**	195.0725**
Error	145	1282.3034	181.1841	0.0750	244.2621	5760.5655	251.7932	53.8079
Mean	—	330.02	105.90	1.67	164.06	250.01	42.61	16.99
Standard error	—	14.62	5.50	0.11	6.38	30.99	6.48	2.99
Critical difference (CD) at 5% level	—	40.52	15.23	0.31	17.69	85.89	17.96	8.30
Range	—	230.96—389.76	76.40—120.55	1.09—2.03	114.38—212.98	85.45—353.73	11.36—71.00	5.03—25.63

** Significant both at the 5% and 1% levels.

Table 2

Estimates of phenotypic variance, environmental variance and different genetic parameters for each of seven agronomic characters of Mesta

Estimates	Characters						
	Plant height (cm)	Basal diameter (cm)	No. of nodes per plant	Days to flower	Stripped green weight (g)	Wood weight (g)	Fibre weight (g)
Phenotypic variance	1687.4366	0.0607	119.8598	466.3052	6465.4885	254.3757	32.5121
Genotypic variance	1473.7194	0.0482	89.6624	425.5948	5505.3943	212.4102	23.5441
Environmental variance	213.7172	0.0125	30.1974	40.7104	960.0942	41.9655	8.9680
Phenotypic coefficient of variability (PCV)	12.45	14.75	10.34	13.16	32.16	37.43	33.56
Genotypic coefficient of variability (GCV)	11.63	13.14	8.94	12.57	29.68	34.20	28.56
Heritability % (h^2)	87.33	79.40	74.81	91.27	85.15	83.50	72.42
Genetic advance (GA)	73.90	0.40	16.87	40.60	141.04	27.43	8.51
Genetic advance as percentage of mean	22.39	24.13	15.93	24.75	56.41	64.37	50.09

heritability (91.27 per cent), followed by plant height, stripped green weight and wood weight, which were almost equal in this respect. Heritabilities for the remaining three characters were between 70 and 80 per cent (Table 2). This indicates that the former three characters might be more helpful for an efficient selection system. JOHNSON *et al.* (1955) reported that heritability values together with the genetic advance were more useful than the heritability alone in predicting the effect of selection.

Stripped green weight exhibited very much the highest genetic advance (141.04) followed by plant height (73.90). The values of GA for wood weight and days to flower were moderately high and were low for other characters (Table 2). The highest genetic advance means that the maximum genetic progress might be expected in stripped green weight. Heritability and genetic advance did not follow the same trend but showed fluctuations. Plant height and stripped green weight had heritability values of a higher order, combined with genetic advances also of a higher order. The association might be due to the presence of additive gene effects (PANSE 1957), indicating that a reasonable amount of progress can be made in the improvement of these characters, which are also main yield components. Basal diameter, number of nodes/plant and wood weight had low values of GA, indicating that the expression of these characters were conditioned by non-additive genes (PANSE 1957).

In order to study the smaller differences, as well as the relative efficiency, in selection among the traits under study, GA as the percentage of the mean will be more meaningful, since it is composed of the selection differential, the GCV (potential advance) and the square root of the heritability (efficiency of the selection system). It was observed that stripped green weight, wood weight and fibre weight had genetic gains of a higher order, indicating that improvement would certainly be possible in these characters. The number of nodes had the lowest GA as a percentage of the mean, indicating less scope for selection since it was under environmental influence. Although plant height, basal diameter and days to flower have comparatively low genetic gains, there is scope for improvement to a limited extent.

Therefore it appears that for stripped green weight, wood weight and fibre weight individual plant selection should be effective and satisfactory for practical purposes.

NEI (1960) pointed out that the genetic systems of the organic characters may never be independent of each other and, therefore, every character is inherited accompanying another character. To measure this statistical phenomenon, the coheritabilities of different pairs of characters under study are presented in Table 3. Days to flower showed a negligible amount of coheritability with other characters, indicating that selection for this character could not

Table 3

Coheritability estimates (%) for every pair of characters under study

Character	Basal diameter	Number of nodes per plant	Days to flower	Stripped green weight	Wood weight	Fibre weight
Plant height	64.72	56.17	15.13	73.58	75.45	74.96
Basal diameter	—	47.04	11.91	78.75	75.06	74.80
Number of nodes per plant	—	—	7.50	56.30	54.20	61.61
Days to flower	—	—	—	7.93	5.50	4.46
Stripped green weight	—	—	—	—	79.54	76.94
Wood weight	—	—	—	—	—	75.73

predict the amount of change in another. It was observed that coheritability estimates of the number of nodes with any other character were moderately high, but other pairs of characters had a relatively high coheritability. This phenomenon suggests that the selection of one of the characters, such as plant height, basal diameter or number of nodes, would result in the simultaneous selection of stripped green weight, wood weight and fibre weight (Table 3).

Acknowledgement

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FRUCTIFICATION AND NUMBER OF SEEDS PER FRUIT IN PEAR VARIETIES

The quality of fructification and the sexual incompatibility of the varieties can be characterized by the number of normally developed seeds capable of germinating. When studying the sterility and incompatibility conditions of pear varieties most authors publish the extent of fruit production and number of full seeds too (Kamlah 1928, Kobel—Steinegger 1934, Kobel *et al.* 1939, Crane—Lewis 1942, Breviglieri—Baldassari 1956, Blaja 1962, Vondracek 1962; in Hungary Nagy 1960, Nyéki 1970 and Brózik—Nyéki 1971). According to the literary data the number and quality of seeds developing in a fruit vary according to the pollen of the pollen variety, which is influenced by the ecological factors of the different years and the condition of the tree.

Comparative data on the fruitfulness of pear varieties and the number of full seeds per fruit are deficient in the literature, only Crane—Lewis (1942) and Nagy (1960) analysed the varieties for these properties.

Crane—Lewis (1942) obtained the following fruit setting percentages and numbers of viable seeds per fruit in pear.

Pollination (♀ × ♂)	Ripe fruit (%)	Numer of viable seeds per fruit
2 × selfing	0.3	1.5
3 × selfing	0.2	0.1
4 × selfing	14.5	4.1
2X × 2X	5.6	6.6
2X × 3X	3.6	3.2
3X × 2X	5.6	1.3
3X × 3X	0.8	0.5
2X × 4X	7.8	5.9
4X × 2X	19.0	5.8

BRITTAIN—EIDT (1933) pointed out in apple that the crossings of 3X × 3X were sterile. When triploids were used as a seed parents, the seeds germinated in a much lower percentage than when the seed parents were diploid.

The number of full seeds and seedlings obtained from the different combinations is important from the aspect of breeding too. BROOKS *et al.* (1967) gave an account of having obtained 0.65 seeds per flower from 71,000 flowers pollinated in the course of crossing pears. According to their calculations 230 hand pollinated flowers are required to obtain 100 seedlings.

The number and quality of seeds determine the amount of yield and the commodity parameters of fruits too. HEINICKE (1917) observed in apple, and TUKEY (1936) in stone fruits that the uneven distribution of the seeds resulted in the asymmetry of the fruits. TUFTS—HANSEN (1933) found a negative correlation between the number of seeds and the length/width ratio of the fruits in Vilmos pear. There was a positive correlation between the number of seeds and the diameter of the fruits. According to SCHANDER (1955c) the fruit index of the pear variety Conference was the larger the more empty seeds were contained in the fruit. SCHANDER (1956) pointed out that the increase of the number of seeds beyond an optimum level no longer results in a further increase of the fruit weight. LUCKWILL (1959) found in certain varieties that the correlation between fruit size and seed number was concealed by an inclination to parthenocarpy, while in other varieties both negative and positive correlations are known. According to the data published by SCHANDER (1956) if the seeds are few in number they have a stimulatory effect on the development of the fruit, while the presence of many seeds may suppress the growth of the fruit due to a contention for the available carbohydrates.

Results of investigations (RODRIGUES 1952, SCHANDER 1955a) show a correlation between the seed number per fruit and the fruit weight, as well as between the seed weight and fruit weight. The number of seeds influences the chemical composition of the fruit and the time of ripening too (LUCKWILL 1959). According to MURNEEK (1954) fruits containing less than 3 seeds drop. VISSER (1955) pointed out that fruit drop in June was in an inverse ratio, while fruit size at harvesting time in a direct ratio to the seed content of fruits.

The results of investigations made in 1968 and 1969 to clear up the fructification conditions of pear varieties were published in 1971 (BRÓZIK—NYÉKI 1971).

In the present work we relied partly on the results of these investigations, partly on further studies performed in 1970 of which the results have not been published so far.

Table 1

The extent of fruit production (%)

Seed parent (♀)	Pollen parent (♂) / Year	Bosc	Clapp	Diel	Dupuit asszony	Harden-pont
		1	2	3	4	5
	1968	—	4.8 : 5.0*	0.0 : —	2.7 : 7.0	3.5 : 4.0
1. Bosc	1969	—	9.9 : 4.8	0.0 : —	3.2 : 2.0	3.9 : 4.2
	1970		—	—	—	—
	1968	—		—	5.0 : 6.0	3.5 : 2.0
2. Clapp	1969	4.2 :8.8	—	0.0 : —	23.2 : 6.6	10.5 : 7.7
	1970	1.4 : 6.0		—	8.1 : 4.0	20.3 : 7.2
	1968	1.8 : 1.0	1.5 : 1.0		0.0 : —	2.9 : 1.5
3. Diel	1969	—	—	—	—	—
	1970	—	0.0 : —		—	—
	1968	12.5 : 7.0	8.6 : 7.4	0.0 : —		11.8 : 5.2
4. Dupuit asszony	1969	3.5 : 4.5	2.3 : 0.0	2.1 : 0.0	—	5.0 : 3.8
	1970	4.3 : 0.0	—	—		—
	1968	—	2.4 : 3.5	0.0 : —	5.5 : 6.5	
5. Hardenpont	1969	15.6 : 5.4	10.2 : 3.0	4.6 : 0.0	10.0 : 6.8	—
	1970	1.7 : 3.2	7.8 : 3.4	—	3.5 : 2.1	
	1968	—	0.0 : —	—	—	0.0 : —
6. Hardy	1970	—	—	0.0 : —	—	—
	1968	—	0.0 : —	0.0 : —	5.4 : 0.0	0.0 : —
7. Nemes Krasszán	1969	—	—	16.7 : 0.0	—	—
	1970	—	—	18.2 : 0.0	—	—
	1969	—	—	3.0 : 1.0	—	—
8. Pap körte	1970	—	—	—	—	—
	1968	—	6.9 : 8.0	—	0.0 : —	0.0 : —
9. Pringalle	1969	8.0 : 6.0	10.6 : 1.6	—	14.1 : 6.2	18.4 : 5.4
	1970	—	12.2 : 3.0	—	3.9 : 8.5	5.5 : 7.8
	1968	0.0 : —	0.0 : —	0.0 : —	3.5 : 1.5	1.9 : 4.0
10. Serres Olivér	1969	—	—	10.0 : 0.0	—	—
	1970	—	2.9 : 0.0	4.4 : 0.0	—	—
	1968	—	—	—	0.0 : —	1.3 : 1.0
11. Téli esperes	1969	—	—	3.3 : 0.0	—	—
	1970	—	3.1 : 0.0	0.0 : —	—	—
	1968	—	4.6 : 2.0	—	0.0 : —	—
12. Vilmos	1969	16.9 : 7.3	12.5 : 4.3	0.0 : —	30.4 : 8.1	12.5 : 7.8
	1970	7.8 : 4.1	5.5 : 2.0	—	8.9 : 6.0	7.4 : 5

Note: * = the first figure is the percentage of fruit production,

The examinations were performed between 1968 and 1970 at the Érd-Elvira station of the Horticultural Research Institute with pear varieties grafted to wild pear seedlings planted in 1953, on five trees per variety.

Of the pollinations made to clarify the conditions of fructification in pear varieties Table 1 presents the fructification percentages and numbers of full seeds per fruit of 12 pear varieties.

For the examinations the flowers were isolated at the white bud stage. The flower buds were isolated at the medium height of the crown with parchment bags of 25 × 35 cm. In each crossing combination 100—500, occasionally even more flowers were pollinated.

and the number of full seeds per fruit

Hardy	Nemes Krasszán	Pap körte	Pringalle	Serres Olivér	Téli esperes	Vilmos
6	7	8	9	10	11	12
2.9 : 3.5			0.0 : —	5.6 : 4.3	11.5 : 4.1	0.0 : —
—	0.0 : —	0.0 : —	0.0 : —	3.6 : 2.8	—	6.9 : 7.0
—	—	4.2 : 1.0	—	—	—	—
0.0 : —	—	—	4.9 : 2.7	—	—	0.0 : —
—	5.4 : 2.0	1.6 : 0.0	12.2 : 7.7	5.8 : 5.0	0.0 : —	14.9 : 2.6
—	—	4.7 : 0.2	2.7 : 1.0	3.4 : 1.0	—	—
2.3 : 0.0	0.0 : —	—	0.0 : —	3.7 : 1.0	0.0 : —	0.0 : —
—	0.0 : —	0.0 : —	—	13.2 : 2.0	11.3 : 2.0	—
3.2 : 2.0	7.1 : 1.6	—	—	5.6 : 2.0	4.7 : 0.7	—
9.5 : 3.2	0.0 : —	—	21.9 : 3.9	13.5 : 6.4	—	10.0 : 6.0
—	—	—	7.5 : 4.8	9.1 : 3.5	—	6.3 : 6.5
—	—	—	—	—	—	—
—	0.0 : —	—	0.0 : —	1.8 : 4.0	6.0 : 4.7	0.0 : —
—	5.9 : 2.0	6.1 : 0.3	16.9 : 6.3	7.0 : 5.0	1.9 : 8.0	15.6 : 5.6
—	—	0.0 : —	9.1 : 5.1	—	—	7.1 : 2.4
—	—	—	2.4 : 10.0	—	—	0.0 : —
—	12.1 : 6.0	—	—	2.1 : 0.0	6.2 : 0.0	—
4.0 : 0.0		—	4.7 : 1.3	4.6 : 1.5	0.0 : —	0.0 : —
3.1 : 1.6	—	5.8 : 1.0	—	13.2 : 0.5	13.3 : 1.3	18.2 : 2.4
2.4 : 0.0		—	—	—	9.1 : 0.0	6.0 : 0.0
—	28.8 : 1.3		—	3.3 - 0.3	37.5 : 2.0	16.1 : 0.6
—	4.1 : 0.2	—	—	7.8 : 0.0	5.7 : 0.1	—
0.0 : —	—	—	—	4.7 : 6.3	0.0 : —	1.3 : 7.0
—	—	17.6 : 0.5	—	14.1 : 5.4	—	9.4 : 5.8
—	—	—	—	—	—	—
0.0 : —	0.0 : —	—	0.0 : —		0 0 : —	0.0 : —
—	6.0 : 4.6	13.3 : 0.0	—	—	11.5 : 5.4	5.7 : 2.7
0.0 : —	3.2 : 0.0	0.0 : —	—		—	—
4.2 : 5.0	—	—	—	0.0 : —		0.0 : —
—	12.5 : 2.1	2.4 : 0.0	—	11.1 : 3.0	—	11.9 : 4.1
4.8 : 0.6	0.0 : —	4.2 : 0.0		6.0 : 0.5		—
0.0 : —	0.0 : —	—	0.0 : —	0.0 : —	—	—
—	25.8 : 4.6	9.5 : 1.0	34.0 : 7.1	11.5 : 5.7	0.0 : —	—
—	—	3.0 : 0.0	2.8 : 7.3	—	—	—

the figure after the colon is the number of full seeds per fruit

Crossing was carried out with the techniques described by RUDLOFF—SCHANDERL (1950) and KOBEL (1954).

The pollination was carried out when the stigmae were shiny, using collected pollen. Pollinations of each combination were performed on five trees per variety, in even distribution according to the four cardinal points. After flowering had been completed — the stigmae turned into brown in the isolators — the isolators were removed. Evaluation of fruit setting was carried out on three occasions: after the clearing and the June fruit drop, and at the time of fruit ripening. The present paper gives the percentage proportion of ripe fruits to the total number of pollinated flowers, for each combination.

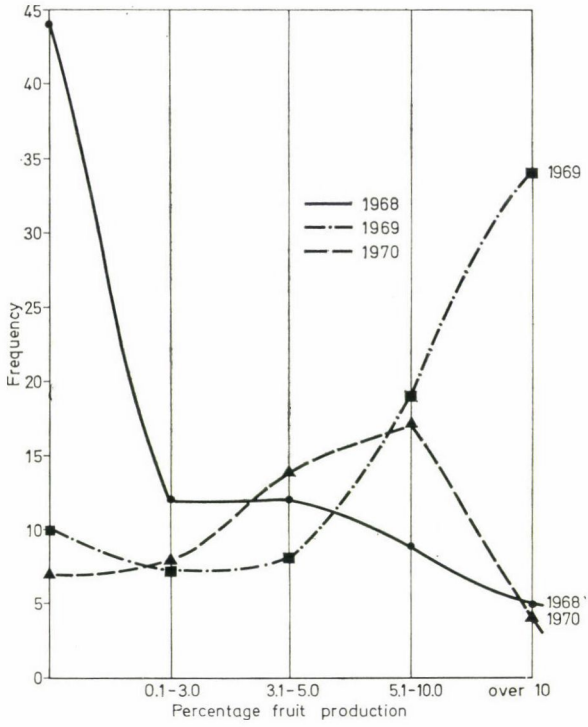

Fig. 1. Frequency of fructification groups (1968—1970)

In ripe fruits originating from various combinations the number of carpels and that of full and empty seeds per carpel were counted. The paper presents the average number of full seeds (containing embryo and endosperm) per fruit for each combination separately. Fruits perfectly free of seed, or only containing tubes consisting of seedcoats were regarded as parthenocarpic.

The extent of fructification and the number of full seeds per fruit are shown in Table 1. In the columns of the Table the first figure represents the percentage of fruit production to the number of pollinated flowers, while the figure after the colon shows the average number of full seeds per ripe fruit.

Table 2 shows the extent of fruit production and the average number of full seeds per fruit in the different combinations. During the investigations the lowest percentage fruit setting was obtained in 1968, and the highest in 1969 (Table 1 and Fig. 1). The average number of full seeds — like the extent of fruit production — varied from year to year. In 1968 the highest number of full seeds per fruit (10.0) was found in the combination of Hardy × Pringalle, in 1969 in Clapp × Bosc (8.8) and in 1970 in Pringalle × Dupuit asszony (8.5).

When comparing the number of full seeds to the extent of fruit production we can see that a poor fructification (lower than 3 per cent ripe fruit) may be accompanied by a high number of full seeds per fruit. E.g. in 1968 in the combination Hardy × Pringalle 10.0 full seeds per fruit were found beside a 2.4 per cent fructification. The same tendency was shown in 1968 by the combination of Pringalle × Vilmos (1.3 : 7.0), and in 1969 by Hardenpont × Téli esperes (1.9 : 8.0).

Table 2

Extent of fruit production and number of full seeds per fruit in the different combinations (1968—1970)

Number of full seeds per fruit	Year	Fruit production (%)			
		1.1—3	3.1—5	5 1—10	over 10
0	1968	1	1	1	—
	1969	4	2	1	2
	1970	4	4	4	1
0.1—1	1968	3	1	—	—
	1969	1	1	3	2
	1970	1	7	2	—
1.1—2	1968	1	5	—	—
	1969	1	1	2	5
	1970	—	1	3	—
2.1—3	1968	—	1	—	—
	1969	—	1	1	5
	1970	—	1	1	1
3.1—4	1968	4	1	1	1
	1969	—	1	1	—
	1970	1	—	2	—
4.1—5	1968	—	2	2	1
	1969	—	2	5	3
	1970	—	—	1	—
5.1—6	1968	—	1	1	1
	1969	—	—	2	6
	1970	1	—	3	—
6.1—7	1968	2	1	1	2
	1969	—	—	2	3
	1970	—	—	—	—
7.1—8	1968	—	—	2	—
	1969	1	—	—	5
	1970	1	—	1	1
8.1—9	1968	—	—	—	—
	1969	—	1	—	1
	1970	—	1	—	—
9.1—10	1968	1	—	—	—
	1969	—	—	—	—
	1970	—	—	—	—

On the other hand, a high percentage fructification (more than 10 per cent ripe fruit) may be accompanied by a low number of full seeds per fruit. In 1969 the following combinations were remarkable in this relation: Pringalle × Pap körte (17.6 : 0.5), Nemes Krasszán × Serres Olivér (13.2 : 0.5), Pap körte × Vilmos (16.1 : 0.6), Pap körte × Nemes Krasszán (28.8 : 1.3) and Nemes Krasszán × Téli esperes (13.3 : 1.3).

Examinations on the seed content were also suitable to point out parthenocarpic fruit setting. The combination of Nemes Krasszán × Diel, Serres Olivér × Diel and Téli esperes × Pap körte showed parthenocarpic fruit setting.

MALIGA (1966) pointed out in quince that the number of seeds was characteristic of the fertilizing ability of the pollen variety, and of the extent of sexual affinity between the two varieties (mother component and pollen donor). According to NAGY (1960) the number of full seeds per fruit — besides the percentage of fruit production — provides further possibilities of comparing varieties for productivity.

The variety whose pollen produces more fruits relative to the number of pollinated flowers is considered a better pollen donor for all varieties. Of two pollen varieties showing the same percentage of fruit production, the one producing more seeds per fruit is regarded as better (MALIGA 1966).

According to our investigations the number of full seeds per fruit was different in the seed varieties. On the average of the years the number of full seeds per fruit was low in the varieties Pap körte, Diel, Nemes Krasszán, Téli esperes and Serres Olivér (below 3.0); medium in Bosc, Dupuit asszony, Hardenpont and Vilmos (3.0—4.0); high in Clapp, Hardy and Pringalle (over 4.0).

When examining the number of full seeds per fruit in the pollen parents, few full seeds (below 3.0) were found in the varieties Diel, Pap körte, Hardy, Nemes Krasszán, Serres Olivér and Téli esperes; a medium number of full seeds (3.0—4.0) in Clapp and Vilmos; and many full seeds (over 4.0) in Hardenpont, Dupuit asszony, Pringalle and Bosc. According to the data obtained by NAGY (1960) in the pear varieties the physiologically more active pollen produced more full seeds.

On the basis of the extent of fruit production and number of full seeds per fruit a one-sided incompatibility was shown by the combinations Bosc × Pringalle and Serres Olivér × Clapp.

Mutual incompatibility between the varieties was observed in the combinations Diel × Dupuit asszony and Serres Olivér × Hardy.

From the results of the investigations the following conclusions can be drawn. In the pear varieties the number of full seeds normally developing in a fruit is suitable for the characterization of the quality of fructification, and the sexual affinity of the mother component and the pollen donor variety. When the number of full seeds is known further possibilities are offered to choose the optimum pollen variety combinations. The pear varieties produced very poor yields and develop few full seeds when the pollen variety is triploid. The number of full seeds per fruit — like the extent of fruit production — varies from year to year in the pollen variety combinations under the influence of the ecological factors. Owing to occasional parthenocarpic fruit formation occurring in pear seed, content examinations are required which are also suitable for sorting out the parthenocarpic, incompatible and interincompatible combinations. When choosing the pollen varieties — taking the simultaneous flowering and extent of fruit production in consideration as well — preference has to be given to pollen donors producing a higher number of full seeds.

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FUNGI ASSOCIATED WITH SEEDLING AND POD-ROT OF PEANUT IN EGYPT

Peanut (*Arachis hypogaea* L.) is one of the most important legumes in Egypt for human consumption. It is subject to several diseases; however, those which cause seedling and pod-rot are the most common and serious. *Rhizoctonia solani* Kuhn and *Sclerotium rolfsii* Sacc. were found to be the most prevalent soil contaminants in this respect (BEATTIE *et al.* 1954, CRUZ *et al.* 1962, CAMPACCI—FIGUEIREDO 1964, MAIN 1966). During infection by these major fungi, several other soil-borne organisms can enter the plant, resulting in more deterioration of the pods either in the field or during storage. Accordingly, storage rots due to these pathogens also constitute another serious problem of peanut production (JACKSON 1963, BARNES—YOUNG 1971).

The causal fungi of seedling and pod-rot in the field and during storage were isolated in the present investigation. Their pathogenicities were also investigated.

Samples of diseased seedlings were collected several days after emergence from different fields in El-Sharkia, Giza and Assiout Provinces. Pre-harvest pod-rots were also isolated from fruits of diseased plants which showed foliar chlorosis. Storage pod-rots were detected from samples of pods gathered from lots stored for 6 months representing different peanut growing areas as well as from The Agriculture Quarantine Warehouses at Alexandria. Isolation was carried out on Martin's rose bengal agar medium, and the developing mycoflora were microscopically examined and identified as usual.

The pathogenic capability of the prevalent fungi tested in sterilized sandy soil in pots, using the peanut Giza 1 variety which was found to be highly susceptible to the disease in the field. Inoculum was added either singly or in all possible combinations.

Inocula were prepared on a sandy-barley medium. Soil infestation was achieved by mixing the inocula with the upper layer of the soil at the rate of 4% of soil weight for seedling infection. The amount of inocula was reduced to 2.4% of soil weight to raise the amount of escaped plants to about 40—50% to give accurate information about pod infection.

Seedling-rot (damping-off) fungi. Fungi associated with diseased peanut seedlings collected from different growing areas are recorded in Table 1.

It is obvious from the data presented that *Rhizoctonia solani* is the most prevalent fungus isolated from diseased peanut seedlings at El-Sharkia and Giza farms. It was found to be in the order of 82 and 78%, respectively, of the examined seedlings from the areas mentioned. On the other hand, this fungus was inferior in its occurrence in seedlings obtained from Assiout fields, as it appeared in about 23% of the examined seedlings. In the latter area however, *Sclerotium rolfsii* was found to be the prevailing fungus attacking peanut growing areas. In the other two Governorates, namely El-Sharkia and Giza, the pathogen was detected at a very low frequency. *A. niger* and *A. flavus* also occurred in association in the diseased seedlings in all the examined areas, with a frequency ranging from 8—49%. *Rhizopus nigricans* was also found in 10—47% of diseased seedlings. *Trichoderma lignorum*, which has been recorded as a parasite for many plant pathogens, was found in all examined areas but with a low frequency (6—12%). Other fungi such as *Penicillium* spp., *Helminthosporium* spp., *Sclerotium batiticola* and the unidentified *Phycomycetes* were also recorded at very low frequencies. Different species of *Fusarium* were also isolated from the previous areas with a relatively high frequency in El-Sharkia (47%), Giza (36%), and Assiout (12%).

Preharvest pod rot fungi. Thirty days before harvest, mature pods collected from diseased plants from fields of the areas mentioned were shelled and the frequency of isolated fungi from diseased shells and seeds was recorded (Table 2).

Results showed that the fungus *R. solani* followed the same pattern in its occurrence in the pods of the diseased plants in El-Sharkia and Giza, but occurs with low frequency in

Table 1

Frequency of occurrence of various fungi associated with seedling-rot of peanut in different growing areas

Fungi	Frequency of seedlings invaded by various fungi		
	El-Sharkia	Giza	Assiout
Rhizoctomia solani	82	78	23
Sclerotium rolfsii	3	3	75
Fusarium ssp.	47	36	12
Sclerotium batiticola	16	13	20
Unidentified *Phycomycetes*	24	24	16
Aspergillus niger	30	49	16
Aspergillus flavus	13	10	8
Rhizopus nigricans	47	26	10
Penicillium spp.	3	8	2
Trichoderma lignorum	10	6	12
Helminthosporium spp.	0	0	9

Table 2

Frequency of occurrence of various fungi found in association in shells and seeds of infected preharvest pods of diseased plants in different growing areas

Fungi	Frequency of pre-harvest pods invaded by various fungi					
	El-Sharkia		Giza		Assiout	
	A	B	A	B	A	B
Rhizoctonia solani	73	31	66	25	27	10
Sclerotium rolfsii	5	3	10	2	67	61
Fusarium ssp.	71	36	76	70	53	40
Sclerotium batiticola	25	10	12	7	42	30
Unidentified *Phycomycetes*	14	5	18	5	4	2
Aspergillus niger	48	27	43	25	41	21
Aspergillus flavus	27	11	10	8	22	13
Rhizopus nigricans	17	0	9	0	4	0
Penicillium spp.	4	0	3	0	2	0
Trichoderma lignorum	13	3	8	0	10	1
Helminthosporium spp.	0	0	0	0	30	15

A = shells, B = seeds

Table 3

Frequency of occurrence of various fungi found in association in shells and seeds of stored fruits from different storages

Fungi	Percentage of stored pods from different storages invaded by various fungi							
	El-sharkia		Giza		Assiout		Alex. Quarant.	
	A	B	A	B	A	B	A	B
Rhizoctonia solani	78	42	71	32	31	19	93	53
Sclerotium rolfsii	8	5	13	9	69	55	12	11
Fusarium spp.	77	48	86	70	55	42	74	63
Sclerotium batiticola	33	27	15	10	42	16	16	11
Aspergillus niger	50	33	49	33	44	41	32	26
Aspergillus flavus	31	21	15	12	29	22	19	15
Aspergillus ssp.	20	15	13	12	11	8	68	43
Rhizopus nigricans	21	2	13	0	8	0	10	0
Trichoderma lignorum	15	6	12	5	17	9	10	7
Penicillium spp.	8	7	7	7	5	4	13	10

A = shells, B = seeds

Assiout. This fungus was generally isolated more frequently from shells than from seeds. *S. rolfsii* was prevalent only in Assiout in both shells and seeds. The other fungi showed the same tendency of occurrence as in the seedlings, but were more frequent in the shells than in the seeds.

Storage pod-rot fungi. Samples from the studied areas, as well as from The Agriculture Quarantine at Alexandria, were shelled, after the usual storing of peanut pods. The frequency of occurrence of fungi from the diseased shells and seeds of visually rotten fruits are presented in Table 3.

The data showed that all fungi isolated from pods before harvest were also recorded during storage. *R. solani* and *S. rolfsii* showed the same high frequencies as mentioned before storage. Shells did not show a significant increase over those of preharvest pods in fungal infection by the indicated fungi, but seed infection has a tendency to increase during storage, specially by storage fungi such as *A. flavus*, and *Aspergillus* spp. as well as *Penicillium* spp. and *Fusarium* spp.

Pathogenic capability of isolated fungi on seedlings and fruits. The pathogenic capability of fungi isolated from peanut seedlings and pods was determined as indicated by the percentage of seedling and pod infection (Table 4).

Results showed that all isolates of both *R. solani* and *S. rolfsii* from the different peanut growing areas were highly pathogenic to the peanut plants, either during seedling or fruiting stages. These fungi showed their high pathogenic capability either alone or associated with the other fungi included in the mycoflora. *Fusarium* spp. were found non-pathogenic to seedlings if present alone, but they were moderately pathogenic during the seedling stage, where about 15% pod-rot was obtained with *Fusarium* isolated from pods collected from Giza. On the other hand, *S. batiticola* was found non-pathogenic to both seedlings or pods

Table 4

The pathogenic capability of fungi isolated from peanut seedlings and pods

Fungi	Seedling damping-off, %	Pod infection, %
R. solani	88	80
S. rolfsii	89	61
Fusarium spp.	0	15
S. batiticola	0	0
A. niger	32	10
A. flavus	18	8
T. lignorum	0	0
R. solani + *S. rolfsii*	100	83
R. solani + *Fusarium* spp.	90	88
R. solani + *S. batiticola*	93	87
R. solani + *A. niger*	97	84
R. solani + *A. flavus*	98	78
R. solani + *T. lignorum*	79	70
S. rolfsii + *Fusarium* spp.	91	70
S. rolfsii + *S. batiticola*	94	65
S. rolfsii + *A. niger*	96	69
S. rolfsii + *A. flavus*	90	66
S. rolfsii + *T. lignorum*	77	51
Fusarium spp. + *S. batiticola*	0	17
Fusarium spp. + *A. niger*	38	23
Fusarium spp. + *A. flavus*	21	18
Fusarium spp. + *T. lignorum*	0	7
S. batiticola + *A. niger*	22	11
S. batiticola + *A. flavus*	22	11
S. batiticola + *T. lignorum*	0	0
A. niger + *A. flavus*	40	17
A. niger + *T. lignorum*	20	9
A. flavus + *T. lignorum*	13	7
Mixed fungi	100	92
Control	0	0

of peanut. Other fungi, such as *A. niger*, were found to be more pathogenic than *A. flavus* to both seedlings and fruits from all areas under study, where the percentage of rotted seedlings ranged between 15 to 32%, while the percentage of pod infection was between 8 to 13%. These figures were increased by the association of these fungi with *Fusarium* spp., *S. batiticola*, or both together. *T. lignorum* was found non-pathogenic to seedlings or pods when present alone in the soil. Its presence however, with other fungi such as *R. solani*, *S. rolfsii*, *A. niger*, *A. flavus* or *Fusarium* resulted in a marked decrease in the percentage of seedling damping-off or pod-infection.

Recently, seedling and preharvest pod-rot has become the most important disease of peanut in Egypt and many other parts of the world. Studying the mycoflora of the infected seedlings and preharvested pods obtained from different localities revealed that *R. solani*, *S. rolfsii* and several other associating fungi were recorded with different frequencies. *R. solani* was found to be the most prevailing fungus in El-Sharkia and Giza, while *S. rolfsii* was the dominant one in Upper Egypt (Assiout). The other associating fungi were *Fusarium* spp., *S. batiticola*, *A. niger*, *A. flavus*, *Rhizopus nigricans*, *Penicillium* spp., *Helminthosporium* spp., *T. lignorum*, and unidentified *Phycomycetes*. Most of them were isolated more frequently from shells than from seeds of rotten pods.

The pathogenicity test revealed that all isolates of *R. solani* and *S. rolfsii* were highly pathogenic to the Giza 1 variety, and typical seedling and pod infection indicates the major role of these two fungi in the incidence of the disease in the studied areas. This gave an idea of to what extent *R. solani* has become widespread throughout all the major peanut growing areas of Egypt producing seedling and pod rot epidemic, especially in those of Lower Egypt.

The present study showed also that *S. rolfsii* was the well acclimatized pathogen responsible for the disease in Upper Egypt. The other fungi associating with the major pathogens were found to be weak pathogens. ASHWORTH—LANGLEY (1964) however, pointed out their important role in disease severity, especially during storage, as they enter the pods with the aid of the major pathogens. Moreover, these minor pathogens may be primary ones in other peanut growing areas of the world due to the prevailing environment, as mentioned by WILSON (1947) and GARREN—HIGGINIS (1947). In this respect, GARREN—WILSON (1951) stated that some minor soil-borne fungi were found to be major seedling and pod-rot pathogens. This indicates the importance of such associating microorganisms in spite of their low frequency at the present time, so that they may predominate when the environmental conditions are favourable, causing another problem.

During storage, the present study showed the occurrence of the fungi mentioned but with an increase of development in the seeds rather than in the shells, particularly with some storage fungi such as *Aspergillus* spp. and *Penicillium* spp. This indicates the importance of these associating fungi in the deterioration of the stored fruits, and also confirms the spreading of the major organisms all over the country.

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COMPARATIVE RESPIRATION STUDIES ON CHERRY AND SOUR CHERRY SEEDLINGS

There are great differences in growth vigour between the cherry and sour cherry in spite of the close relationship between them. The shoots of the cherry are of strong apical dominance, the crown generally extends upwards, and the trees become tall and spreading. By contrast, the apical dominance of the sour cherry is moderate, its crown shape is shrub-like, and the trees are smaller and shorter.

The phenotypic manifestation of the different genetic features is based on differences in the metabolism (including hormone balance), and characteristic differences in the respiratory metabolism can certainly be demonstrated. Such "metabolic indices" could perhaps be taken into consideration for practical purposes, e. g. in selection.

The respiratory metabolism of the vegetative parts seemed to be suitable for demonstrating characteristic differences, so the following examinations were carried out. By means of the so-called two-dimension respirometer (FREWIL apparatus) we were able to determine in a few minutes the respiratory carbon dioxide production of intact plants at various points of the vegetative parts, of which the collar zone, the internodes and the buds were taken into consideration for the purpose of comparison.

The examination were performed at the end of 1975 and the beginning of 1976 on cherry and sour cherry seedlings in the juvenile stage. The rooted seedlings were transferred from the field to the laboratory of the Department of Plant Physiology, Eötvös Loránd University in the middle of December and kept there for the period of the examination in pots of adequate size filled with earth, at room temperature, under conditions of natural illumination.

Bud bursting began in a few days, mostly in the apical parts of the shoots, while the buds near the collar remained dormant for a longer time.

The examinations were carried out with the above-mentioned FREWIL apparatus (FRENYÓ 1974a, b; 1975); the two species were compared for the respiration in identical organ parts.

The respiratory carbon dioxide of the different parts was collected in 0.5 ml gas recipients, whose openings were attached in an air-tight manner to the surface of the tissue (Fig. 1).

By opening the taps of the recipients gas samples were taken for 3 minutes each from the air space of the plant part concerned. The carbon dioxide content increased with the intensity of respiration. The recipient was then closed again, and electrometric measure-

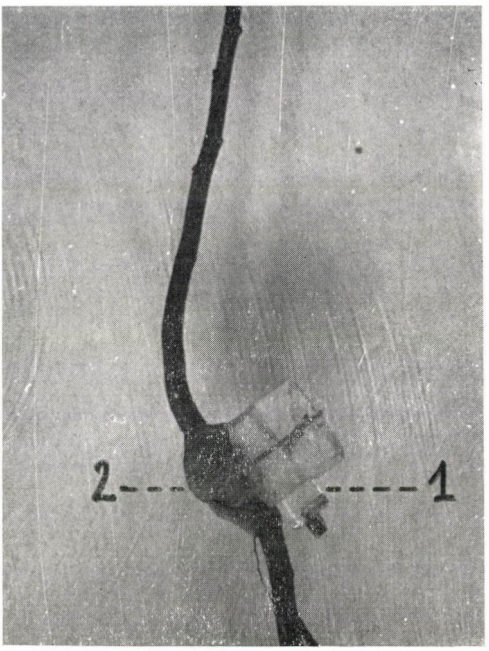

Fig. 1. Air-tight attachment of a gas recipient to the surface of the collar for collecting respiratory carbon dioxide. 1: Tap of the gas recipient; 2: sealing-compound (plastiline)

ments were made, using the FREWIL apparatus, on the amount of carbon dioxide discharged in 3 minutes from a 1 cm^2 area of the plant part (Figs. 2 and 3). Either the microgramme values obtained were reduced by 0.3 μg to correct for the value of the air contained in the gas recipient, or the carbon dioxide content of the air in the gas recipient was removed in advance, in which case the correction was unnecessary.

Besides measuring the respiration, histological examinations were also carried out in order to determine the ratio of living to dead parts, and the components of the cells.

A total of some 50 measurements were made from 30th December 1975 to 7th January 1976 on the intact collars (approx. 1 cm in diameter) of sour cherry and cherry seedlings, on the internodes of the stem and on the buds. The measurements were made in all cases on a more or less uniform (1 cm^2) area. In general, we found that in both species respiration at the time of the examination was the most intensive at the collar zone, while the internodes discharged only about half as much carbon dioxide per cm^2 of surface. Respiration was similarly low in buds just beginning to revive from dormancy; the carbon dioxide production of a bud was about as much as that of a periderm-covered internode over a similar area. The actual values are shown in Fig. 4.

The amount of respiratory carbon dioxide produced in 3 minutes was noticeably different in all examined parts of the two related species, and similar results were also obtained when respiration was examined over a longer period, by neutralizing a low concentration phenolphtalein NaOH solution with the product of respiration emitted for hours from the intact surface of the collar (FRENYÓ 1954). The results of the measurements were mutually confirmed by the fact that the ratio of 1.6 obtained over a longer period of measurement for the respiration intensity of sour cherry and cherry at the collar zone deviated only very slightly from the results of the 3-minute measurements. In the latter case the ratio was 1.7;

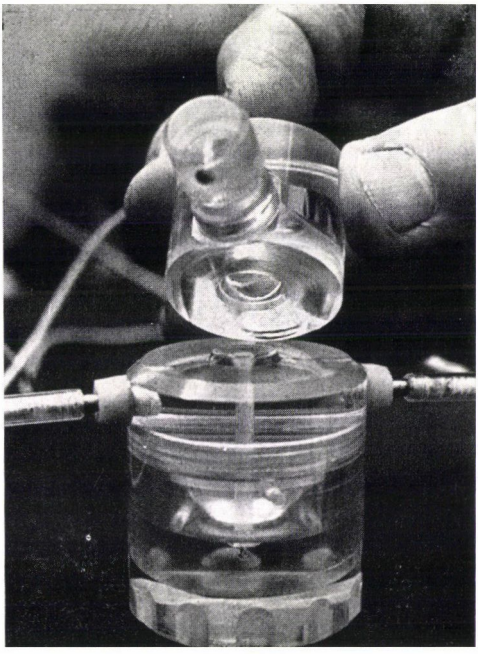

Fig. 2. Fitting the closed gas recipient containing respiratory carbon dioxide to the probe of the FREWIL apparatus

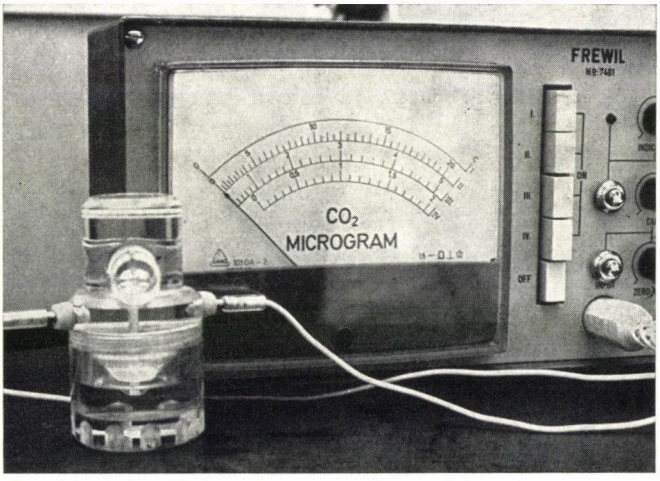

Fig. 3. The apparatus ready for measuring

that is, the respiratory carbon dioxide production of intact tissues in sour cherry forced at room temperature during winter post-dormancy was 1.6 or 1.7 times as high as in similarly treated cherry.

The instrumental comparison of respiration under the same conditions produced a ratio of 3.2 for the internodes of the stem, and 2.4 for lateral buds just beginning to burst, in favour of sour cherry.

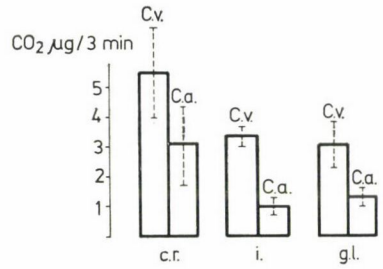

Fig. 4. Results of respiration measurements on various parts of sour cherry (*Cerasus vulgaris* = C.v.) and cherry (*Cerasus avium* = C.a.). c.r. = Collum radicis (collar); i. = internode; g.l. = gemma lateralis (lateral bud)

As such measurements have not yet been carried out on intact plants, we still do not know how the ratio of respiration intensity between sour cherry and cherry changes during the vegetative period. Nor do we know the value (RQ) of CO_2/O_2, because with the FREWIL apparatus only the CO_2 emission can be measured, while the amount of O_2 uptake remains unknown.

In spite of the dispersion of data the intensity of respiration measured at the collar zone was found to give the most readily reproducible results, since this is a well-defined part of the plant, while the internodes and buds are in different biological states depending on their distance from the shoot apex. In our work we endeavoured to compare internodes in as near the same position as possible and buds in as near the same position and state as possible in the two species.

There were unquestionable differences in respiratory metabolism between the two species. The fact that the intensity of respiration is higher in sour cherry than in cherry, at least under the conditions of the experiment, calls for an explanation. On studying the possible mechanism of rootstock effect in a literary review BEAKBANE (1956) calls attention to the importance of the amount of living tissue compared to tracheae and supporting tissue, since the proportion of living tissue in the root is higher in dwarfing root stocks. However, his statement that a large amount of living tissue compared to the plant surface causes an internal oxygen deficiency resulting in reduced respiration is questionable. He refers to Hassan, who made a physiological comparison between dwarf apple root stocks and those of intensive growth habit and found the rate of respiration to be faster in the latter than in the former.

Our present paper agrees only in part with Beakbane's opinion. We examined the ratio of living to dead parts in tissue sections of sour cherry and cherry displaying different intensities of respiration, and found more living tissue in the collar and internodes of sour cherry, which when intact showed a higher respiratory activity than cherry. The same result is indirectly suggested by our earlier paper (BRUNNER—NYÚJTÓ—ANTONI-GÁL 1968), in which Table 1 shows the ratio of cortex + phloem in the root sections of cherry and sour cherry; it is 14.33% for cherry and 20.35% for sour cherry relative to the whole cross section. The sieve tubes and other living tissues (phloem parenchyma, etc.) undoubtedly have a respiratory metabolism. It seems natural to us, however, that the larger the proportion of living components the higher the intensity of respiration. This partially explains the higher intensity of respiration (carbon dioxide emission) in sour cherry compared to that in the corresponding tissues of cherry.

Histological examinations connected with the present paper led to the important conclusion that while the cherry contained large quantities of starch stored in the cells of

the phloem parenchyma and medullar rays, in sour cherry even an iodine test made at the same time was only able to demonstrate a small quantity of starch. It may well be that the phenomenon was connected with the increased rate of respiration in one of the following ways: either the higher intensity of respiration promoted the transformation of starch into sugar, or the increased sugar level caused by the activity of amylase had a stimulatory effect on respiration. The question remains to be settled, as does that of whether the respiration study described in this paper can be used for pre-selection.

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THE STABILITY CONSTANTS OF Zn-, Fe- AND Cu-HUMIC ACID COMPLEXES AT DIFFERENT pH VALUES

The fate of a particular metal ion in the soil, that is, whether it will be translocated or deposited or under what type of conditions it will be available to plant roots and/or to biological systems, will often depend on the relative stability of the combinations or complexes it forms. Soil organic matter forms complexes with metals by ion exchange, surface adsorption, chelation and complex formation. The stability of metal chelates and their effectiveness in supplying micronutrients to plants differ widely from one metal to the other and are largely dependent on soil properties such as pH and soil texture (Randhawa—Broadbent 1965, Ovcharenko—Gordienko 1969, Abdel-Latif 1973).

The present work deals with the stability of Cu-, Fe- and Zn-humic acid complexes at different pH values.

Extraction of humic acid. A soil sample was taken from Shalakan, in the southern part of the Nile Delta, to represent the alluvial soils of Egypt. The soil was air dried, ground, passed through a 2 mm sieve, mixed, and stored in polyethylene bottles. Humic acid was extracted from the soil using 5 : 1 NaOH (0.5 *N*) to soil at 26°C by the method of CHOUDRI—STEVENSON (1957). The humic acid fraction was separated by adjusting the extract to pH 1.0 using 1.0 *N* HCl and centrifuging at 6000 rpm for 20 min according to POSNER (1966). The humic acid was redissolved in 0.5 *N* NaOH, reprecipitated by acidification to pH 1 and electrodialysed against distilled water, using a cellophane membrane, until it was chloride-free.

Determination of stability constants. Aliquots of 1, 2, 3, 4 and 5 ml of humic acid stock solution (5 mg HA/ml) were transferred to a 50 ml Pyrex beaker and the volume was made up to 30 ml with distilled water; then 5 ml of 1.0 *N* KCl and 3 ml of Cu- Fe- and Zn-chloride solutions containing 100 μg metal per ml were added separately to each beaker and the pH was adjusted with potassium hydroxide or hydrochloric acid to 4.0, 5.5 and 7.0. One series of flasks received no humic acid. The solutions in the beakers were transferred to 50 ml volumetric flasks.

One gram of potassium-saturated cation-exchange resin (Amberlite IR-120, 16—25 mesh) was placed into each 250 ml bottle. A solution containing either Cu, Fe or Zn chloride, potassium chloride, and different quantities of humic acid were transferred to the bottles and shaken for one hour. The exchange resin was then removed by filtration and the filtrate plus the washings with distilled water were taken to dryness on a steam bath and then digested with a mixture of 5 : 1 concentrated HNO_3 and H_2SO_4. The residue was dissolved in 10 ml of 0.6 *N* HCl solution and brought to 50 ml volume. Cu, Fe and Zn were determined using the Unicam atomic absorption spectro-photometer.

The saturation capacity of complexing sites on humic acid was determined according to the method described by RANDHAWA—BROADBENT (1965). To 25 mg of the stock solution of humic acid, 5 mg of either Cu, Fe or Zn (in the form of chloride) and 2.5 ml of 1.0 *N* potassium chloride solution were added in a 50 ml Pyrex beaker. The pH was adjusted to 4.0, 5.5 and 7.0, and the contents were transferred to 25 ml measuring flasks and filled to the mark with distilled water. They were shaken for two hours and centrifuged in a high speed centrifuge (17,000 rpm). The supernatant was spun down and Cu, Fe and Zn were determined in the supernatant using Unicam SP 90 atomic absorption.

The stability constant is a thermodynamic constant defined by the equation:

$$K = \frac{(MCh_x)}{(M)\ (Ch)^x}$$

where: K = the stability constant,
(Ch) = the concentration of complexing agent in moles per litre,
(M) = the molar concentration of metal ion,
x = the number of moles complexing agent Ch which combines with one mole of metal.

Applying this equation to the metal organic matter complex the values of both x and Ch are unknown. However, the stability constants for copper, iron, and zinc-humic acid could be calculated using the equation given by MARTELL—CALVIN (1959):

$$\log (\lambda_0/\lambda - 1) - \log K + x \log (Ch)$$

where:

λ_0 = the distribution constant for exchange of a metal between solution and a cation-

exchange resin (MR/M); MR is the amount of cation bound to a definite amount of resin, and M is the molar concentration of metal ion.

λ = the distribution constant in the presence of chelating agent $= \frac{MR}{M + MCh_x}$.

Measuring λ_0/λ with more than one value of Ch, x may be obtained directly from the slope of $\log(\lambda_0/\lambda - 1)$ versus $\log(Ch)$ using the relative concentration of Ch. When the maximum complexing ability of humic acid is determined, (Ch) and consequently K could be calculated. Ionic strength should be kept constant when concentrations are used instead of activity.

The distribution of Cu, Fe, and Zn between cation-exchange resin and their equilibrium solutions in the absence of humic acid is shown in Table 1. It is noted that the adsorption of Cu, Fe, and Zn on cation-exchange resin increased as the pH increased.

Table 1

Distribution of Cu, Fe, and Zn ions between Amberlite IR-120 cation-exchange resin and equilibrium solution at different pH values

pH of equilibrium solution	Metal in solution (M) μM/L			Metal adsorbed on resin (MR) μM		
	Cu	Fe	Zn	Cu	Fe	Zn
4.0	11.20	9.00	12.20	4.15	4.92	3.98
5.5	9.40	5.40	6.80	4.24	5.10	4.25
7.0	7.80	1.80	6.20	4.32	5.28	4.28

Table 2 gives the values of Cu, Fe, and Zn in solution and those adsorbed on the cation-exchange resin in the presence of different amounts of humic acid at pH values of 4.0, 5.5 and 7.0. The data show that the affinity of humic acid for Cu exceeded that for both Fe or Zn at pH 4.0. At pH 5.5 and 7.0, the affinity of humic acid for Fe exceeded that for both Cu and Zn, and the affinity for Cu exceeded that for Zn. It is also noticed that the concentration of the metal in solution represents the free metal plus that complexed by humic acid. The data also reveal that all three metals are complexed quite strongly by humic acid. Also, the values show that as the quantity of humic acid increases, the amount of the metal adsorbed on the cation-exchange resin decreases; the amount combined with humic acid also increases as the pH increases.

These findings agree with the results of RANDHAWA – BROADBENT (1965). They reported that in a reaction between a metal ion and a complexing or chelating agent, the metal may be considered as an electron acceptor, and the complexing agent denotes an electron pair. Complexing agents, which may be considered as Lewis bases, have a considerable affinity for hydrogen ions as well as for metal ions. Hydrogen ions compete with metal ions for the ligand, so that a decrease in pH results in a reduction of the free ligand concentration, and a decrease in the amount of metal complexed. In other words, at higher pH values more complexing sites on the humic acid molecules were available for combination with Cu, Fe and Zn.

The number of moles of humic acid which combined with one mole of metal was calculated from the linear relationship of the log of the relative concentration of complexing agent and $\log(\lambda_0/\lambda - 1)$ on a log–log scale. The data are tabulated in Table 3. Results indicate that the humic acid/Cu ranges between 1.86 and 1.90 at pH 4.0 – 7.0 (Fig. 1). This indicates that Cu is chelated by humic acid mainly in the divalent form, and only a very small per-

Table 2

Distribution of Cu, Fe, and Zn ions between Amberlite IR-120 cation-exchange resin and their equilibrium solutions in the presence of different concentration of humic acid at pH values of 4.0, 5.5 and 7.0

Humic acid	Metal in solution (M) + (MCh_x) μM/L			Metal adsorbed on resin (MR)		
mg	Cu	Fe	Zn	Cu	Fe	Zn
			At pH 4.0			
5	31.40	15.60	13.00	3.14	4.59	3.84
10	45.00	36.60	30.00	1.96	3.54	3.09
15	70.80	49.00	35.20	1.17	2.92	2.83
20	78.60	69.40	44.00	0.78	1.90	2.39
25	80.20	76.00	53.60	0.70	1.57	1.91
			At pH 5.5			
5	51.20	21.80	19.20	2.15	4.28	3.63
10	66.80	64.80	31.40	1.37	2.13	3.02
15	78.60	82.80	49.80	0.78	1.23	2.10
20	86.60	91.80	55.00	0.38	0.78	1.84
25	89.20	95.60	66.60	0.26	0.59	1.26
			At pH 7.0			
5	52.00	60.80	23.00	2.11	2.33	3.44
10	70.00	76.00	42.00	1.12	1.57	2.49
15	38.40	90.40	54.20	0.54	0.85	1.88
20	88.80	93.80	65.80	0.27	0.68	1.30
25	91.20	99.20	76.40	0.15	0.41	0.77

centage is chelated in the monovalent form. With iron, this ratio varies between 1.92 and 2.13 with small and irregular changes with pH, indicating that Fe is adsorbed mainly in the divalent form (Fig. 2). It should be mentioned, however, that the ferric ion and, to some extent, the ferrous ions form a number of hydroxy chelates in which one or more hydroxyl ions become directly co-ordinated with the metal as auxiliary ligands (MARTELL 1952). The number of moles of humic acid combined with each mole of zinc increases with pH and ranges between 1.26 at pH 4.0 to 2.0 at pH 7.0. Results indicate that at pH 4.0 about 75% of the zinc is complexed in the monovalent form and about 25% is complexed in the divalent form. At pH 5.5 the monovalent zinc reached 50%, whereas at pH 7.0 almost all the zinc was complexed in the divalent form (Fig. 3).

These results tend to confirm the findings of ABDEL-LATIF (1973), who found that the number of moles of humic acid combined with one mole of iron ranged from 1.97 to 2.03 at pH 7.0. RANDHAWA—BROADBENT (1965) found that the number of moles of humic acid

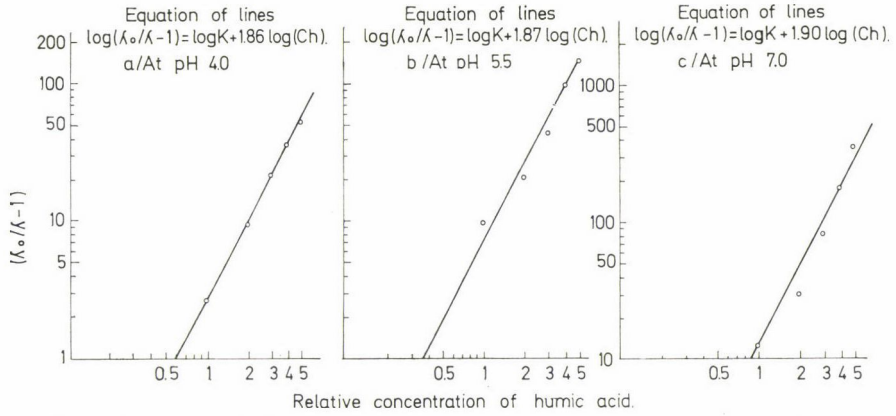

Fig. 1. **Determination of ionic species of copper adsorbed on humic acid at different pH values by the cation-exchange resin equilibrium method**

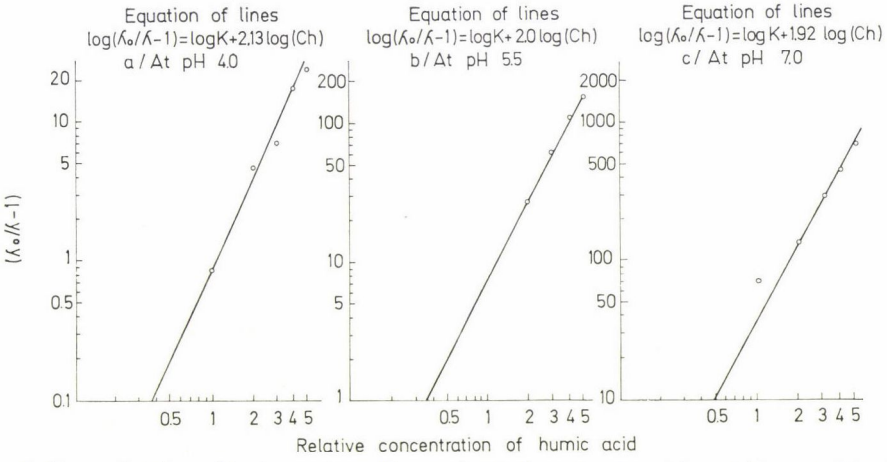

Fig. 2. **Determination of ionic species of iron adsorbed on humic acid at different pH values by the cation-exchange resin equilibrium method**

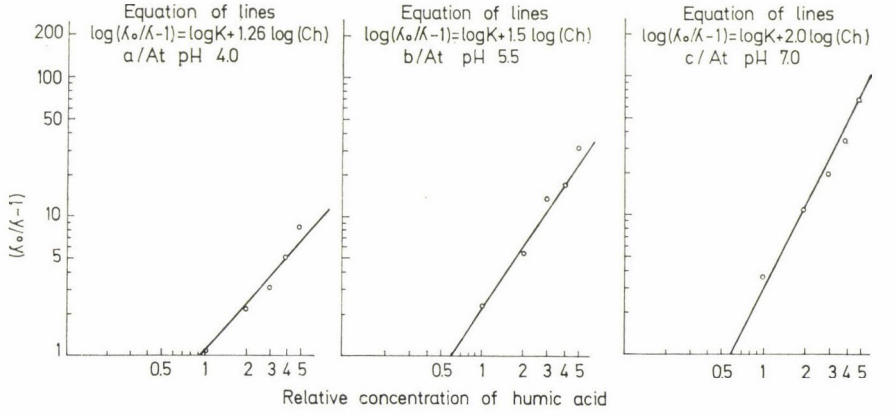

Fig. 3. **Determination of ionic species of zinc adsorbed on humic acid at different pH values by the cation-exchange resin equilibrium method**

Table 3

Number of moles of humic acid combined with one mole of metal at pH values 4.0, 5.5 and 7.0

pH of equilibrium solution	Moles of humic acid combined with one mole metal		
	Cu	Fe	Zn
4.0	1.86	2.13	1.26
5.5	1.87	2.00	1.50
7.0	1.90	1.92	2.00

Table 4

Maximum number of complexing sites for Cu, Fe and Zn on 5 mg humic acid

pH of equilibrium solution	Maximum complexing sites of metal μM/L on 5 mg humic acid		
	Cu	Fe	Zn
4.0	318	692	76
5.5	412	696	276
7.0	532	580	396

combined with one mole of zinc was 1.25, 1.59, and 1.70 at pH values of 3.6, 5.6 and 6.9, respectively.

The difference in the co-ordination number of these metals may offer an explanation for the difference in the humic acid/metal ratio. The sites of functional groups on the humic acid affect the ratio; MARTELL—CALVIN (1959) reported that the number of chelate donor groups that can combine with a metal ion corresponds to the co-ordination number of that ion.

The saturation capacity of complexing sites on humic acid was determined by shaking the chelating agent with an excess amount of metal salts and by centrifugation. The supernatant was spun down, the metal was determined and the saturation capacity was calculated by subtracting the amount of metal in the supernatant from that added before shaking. The maximum complexing ability of humic acid is reported in Table 4. The data indicate that the maximum number of complexing sites on humic acid with different metals was in the order Fe > Cu > Zn at pH values 4.0, 5.5 and 7.0.

The stability constants of Cu, Fe and Zn chelated with humic acid are given in Table 5. The values indicate that stability constants of metal with humic acid followed the order Cu > Fe > Zn at pH 4.0 and 5.5. At pH 7.0 the stability constants of metal with humic acid followed the order Fe > Cu > Zn. These findings agree with those of OVCHARENKO—GORDIENKO (1969). They reported that the stability of metal complexes formed in aqueous solution followed the order Fe > Cu > Zn. ABDEL-LATIF (1973) found that the stability constants (log K) for Fe–humic acid complexes ranged between 6.65 to 7.59 at pH 7.0. He also found that the stability constant (log K) for Zn-humic acid complexes ranged between 5.06 to 5.92 at pH 7.0. RANDHAWA—BROADBENT (1965) found that stability constants between zinc and humic acid were 4.42, 6.18, and 6.80 at pH values 3.6, 5.6 and 6.9 respectively.

Table 5

Maximum number of complexing sites for Cu, Fe and Zn on 5 mg humic acid

pH of equilibrium solution	Maximum complexing sites of metal μM/L on 5 mg humic acid		
	Cu	Fe	Zn
4.0	318	692	76
5.5	412	696	276
7.0	532	580	396

LEHMAN (1963) showed that there were a number of factors affecting the stability of metal chelates, namely, the number of rings formed by one molecule of chelating agent with the metal ion, the size of the rings and the nature of the donor atoms.

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COMPARATIVE STUDY ON THE HYDROGEN CYANIDE CONTENT OF LOTUS CORNICULATUS AGG. IN HUNGARY

Increased attention has recently been paid to the biochemical characters — e.g. the presence or absence of cyanogenic compounds — which can be used to demonstrate relationships between the taxons (GRANT—SIDHU 1967). For some decades extensive investigations have been made to demonstrate the presence of hydrogen cyanide (HCN) in papilionaceous fodder plants. Of the large number of relevant theoretical and experimental works only those dealing with the genus *Lotus* and some other closely related papilionaceous species (*Trifolium*, *Vicia*, etc.) are mentioned. Particular attention has been paid to *Trifolium* species (CORKILL 1940, 1942, 1952, MELVILLE *et al.* 1940, DADAY 1954a, b, 1955, 1958, 1965, ROO 1963, AKBARI 1965, JONES 1966, BISHOP—KORN 1969, MITCHELL 1974, MAHER—HUGHES

1971, etc.); many authors have examined various *Lotus* species (DAWSON 1941, SMIRNOVA-IKONNIKOVA—MUKHINA 1956, GRANT 1967, GRANT—WHETTER 1966, GRANT—ZALITE 1967, GRANT—SIDHU 1967, GIBBS 1963, JONES 1962, 1966, 1968, 1970, 1972a, b, 1973, BUTLER 1965).

Having studied the geographical distribution of the genus *Lotus*, GIBBS (1963) showed all *Lotus* species living in North America to be acyanogenic, while those in the Old World are mostly cyanogenic. He thus felt justified — on the basis of many other characteristics too — in placing the former in the genus Hosackia as opposed to the European *Lotus* species. GRANT —SIDHU (1967) carried out quantitative analyses in diploid and tetraploid *Lotus* species (some 54 taxa) of the Old and New World concerning the intensity of the hydrogen cyanide reaction. They found the intensity of the reaction to vary to a great extent in different *Lotus* species, from negative (acyanogenic type) to highly positive (cyanogenic type). The mean value of the HCN reaction is higher (5.71) in the European than in the American species (3.33). In contrast to Gibbs they found a positive HCN reaction in some North American species and a negative reaction in several *Lotus* species of the Old World. They gave evidence of the HCN reaction being higher in fresh green leaf material than in air-dry material or in old (approx. 70 year old) herbarium specimens.

Other authors — e.g. SMIRNOVA-IKONNIKOVA—MUKHINA (1965) — carried out investigations in cultivated cultivars of *Lotus corniculatus* in different phases of ontogeny, as well as at different development stages after repeated cutting. For example, the HCN content of the variety Morshanski-528 showed a considerable increase from the first to the third cutting and only decreased after the fourth curring. In other varieties, on the other hand, the HCN content was found to be of increasing tendency after all four cuttings. During observations made in 1929 Querin found the flowers of *Lotus corniculatus* to be cyanogenic (QUERIN 1929). Later some other authors also reported a higher HCN content in the flowers (during the main flowering period) so the green crop can be used as green fodder mainly before budding and flowering, while during budding and flowering it is used as dried fodder or silage. For example, the leaves of the variety Morshanski-528 contain 4.9 mg%, while flowers at their first opening contain 13.1 mg% HCN.

A highly complicated problem studied by many authors is the cyanogenic polymorphism of different plant species. There are abundant literary data on the cyanogenic polymorphism of the *Lotus* and *Trifolium* species (JONES 1962, 1966, 1968, 1970, 1972a, b, 1973, ANGSEESING—ANGSEESING 1973, CRAWFORD-SIDEBOTHAM 1972, etc.). Examining the HCN content of wild *L. corniculatus* L. ecotypes in England, Holland, Denmark, etc., Jones made valuable observations and comparisons concerning the presence of cyanogenic and acyanogenic types. In his work "Co-evolution and Cyanogenesis" published in 1973 a summary of these problems is given with abundant literary references. According to Daday's investigations, temperature plays an important role in maintaining cyanogenic polymorphism in *Trifolium repens*. Mild winters are favourable for cyanogenic plants, and low winter temperatures for acyanogenic ones. For example, the European occurrence of the cyanogenic type of *Trifolium repens* shows an increasing frequency from North-East to South-West. According to JONES (1970) it is more probable that, in the case of *Trifolium repens*, the cyclic effect of temperature is felt. Jones studied the effect of temperature on the frequency of cyanogenic forms, but found the methods available at present to be too rough for such investigations.

It has been pointed out that the four phenotypes of cyanogenesis can be found in the leaves as well as in the flowers of *Lotus corniculatus*. They are:

1. cyanogenic glucoside + enzyme — cyanogenic type — amara,
2. cyanogenic glucoside without enzyme — acyanogenic type — dulcis,
3. enzyme without cyanogenic glucoside — acyanogenic type — dulcis,
4. neither enzyme nor cyanogenic glucoside — acyanogenic type — dulcis.

The aim of our investigations was the determination of the hydrogen cyanide content of wild taxa and cultivated cultivars of *Lotus corniculatus* growing in Hungary. Among the ecotypes of wild *Lotus corniculatus* we tried to find low HCN content or acyanogenic plants, which could be used as starting material in plant breeding or may even be regarded as gene reserves of the natural flora for the Hungarian gene bank.

In our investigations 10 cultivated and 6 wild taxa belonging to the morphological range of *Lotus corn.* agg. in Hungary were included. They were: Viking, G-narrow leaved, Empire, Gülzower, Táborszky, Kubansky-44, local varieties from Ják and Nagykálló, as well as erect and procumbent types selected from a wild *Lotus tenuis* population and grown by Gondola. The wild plants were: *L. corn.* ssp. *corn.* var. *corniculatus*, var. *dabasensis*, ssp. *hirsutus* var. *hirsutus* and var. *pilosus*, *L. tenuis* and *L. borbasii*.

From the different methods used by the above authors for determining the HCN content we chose a rapid method for our experiments, highly suitable for the serial examination of a large volume of comparative material. This method was first applied and described by DAWSON (1941), then with some modification by JONES (1966), GRANT—WHETTER (1966), GRANT—ZALITE (1967). Its essence is as follows.

Filter paper strips of 3.0×0.9 cm were placed in small glass tubes (of 1.55×5.0 cm) filled with Na-picrate solution (50 g Na_2CO_3 was dissolved in 1 lit. water, then 5 g picric acid was added and the solution was filtered) in such a way that they were in contact with the plant material placed in the bottom of the tube. In each case 0.05 g plant material was used. Then 3—4 drops of toluol per tube were added, the tubes were closed hermetically and incubated at 25°C. The presence of HCN was indicated by the colour reaction of the filter paper saturated with yellow picrate solution. The reaction could be observed after 48 or 24 hours (the latter period of incubation also proved to be sufficient), therefore it was then that the results were evaluated. The colour reaction appears during the release of HCN on the filter paper in 10 grades from light (lemon-)yellow to dark brick-red. The minus (—) sign indicates the absence of HCN, i.e. a negative reaction; in such cases the filter paper retains its original lemon-yellow colour. This reaction is given by the acyanogenetic types. The $\pm$ sign indicates an uncertain positive reaction, while the values from $+1$ to $+8$ indicate increasing positive reactions. Plants giving such reactions are of cyanogenetic type. The 10 colour grades, using KCN as the standard equivalent, are: $- = 0.0005$, $\pm = 0.001$, $+1 = 0.001—0.0025$, $+2 = 0.0025$, $+3 = 0.005$, $+4 = 0.025—0.05$, $+5 = 0.075$, $+6 = 0.1$, $+7 = 0.25$, $+8 = 0.75$.

Thus, taking the KCN equivalent as a basis, the HCN content of each gramme of leaf or flower material varies from 0.5 μg to 750 μg.

Having tested the method, we started the examinations at the flowering stage in 1974. We compared the HCN reactions of various taxa in plant materials obtained from the middle of the shoot and foliage leaves on the one hand, and in flowers on the other.

Three parallel series were set up: with fresh plant material, and with materials dried for 48 hours at room temperature, and for 48 hours at 110°C, respectively (in each of the three series 0.05 g material was used). The analyses were made in July and September, in three successive weeks of each of the two months. The first period of measuring — 5th, 12th and 17th July — coincided with the time of mass blossoming, while the second — 6th, 13th and 19th September — with the development and second flowering of the aftercrop following the August cutting. In the evaluation the mean value of the measurements obtained in the two periods was taken into account.

In 1975 the examinations were scheduled in such a way as to study the spring period of vegetative development omitted in the previous year, and the initial phase of flowering. Accordingly, measurements were carried out on 20—22nd May and 13—15th June. After this the crop was cut, and measurements of the after-growths were next taken on 24—26th

Table 1

Average HCN-reaction values of Lotus taxa on the basis of data obtained on 5th, 12th, 17th July and 6th, 13th, 19th September 1974.
I = fresh material, II = material dried for 48 hours at room temperature,
III = material dried for 48 hours at 110°C
a = leaf(+shoot); b = flower; 0.0 = (−) negative reaction;
0.1—0.9 = (±) uncertain positive reaction

Taxon	July						September					
	I.		II.		III.		I.		II.		III.	
	a	b	a	b	a	b	a	b	a	b	a	b
53.	5.8	5.5	5.6	5.1	1.8	2.3	6.1	4.8	6.0	4.0	1.1	0.7
54.	5.5	6.0	4.6	5.0	1.8	1.0	5.3	4.7	5.3	4.6	0.6	0.1
55.	5.8	7.0	4.6	4.5	0.0	1.3	7.0	7.5	7.0	5.0	0.5	0.7
56.	5.5	6.0	4.8	6.0	1.3	0.2	6.6	6.0	6.5	5.5	0.6	0.7
58.	5.0	5.3	5.0	4.8	0.8	1.0	7.0	5.0	3.8	3.0	0.1	0.0
60.	5.1	6.5	4.8	5.1	1.8	1.6	6.6	6.7	5.3	5.5	0.3	0.2
61.	6.8	6.6	5.1	5.0	1.8	1.3	6.3	6.5	5.6	5.5	0.6	0.1
62.	5.3	6.0	5.1	5.0	2.3	2.1	7.3	6.2	7.0	6.0	0.5	0.1
74.	5.5	6.0	5.5	5.1	1.5	1.3	7.1	6.0	6.8	5.5	0.3	0.1
75.	6.3	6.6	5.3	5.1	2.0	2.3	6.8	5.0	6.6	3.5	0.5	0.1
100.	0.25	5.8	0.8	4.8	0.0	1.3	0.0	4.0	0.0	1.5	0.0	0.0
101.	6.7	5.5	3.5	2.5	2.5	0.7	7.0	5.0	6.3	5.0	0.1	0.0
101a.	5.0	7.2	4.0	2.0	2.2	0.7	0.0	—	0.1	—	0.0	—
110.	4.0	5.8	4.0	4.3	2.1	1.5	8.0	5.0	7.6	1.0	0.8	—
111.	5.6	5.5	5.5	4.6	2.0	2.1	6.3	6.0	6.0	4.0	0.6	—
112.	5.5	6.0	3.3	5.2	1.0	3.0	—	—	—	—	—	—
113.	1.6	4.0	1.5	3.0	0.8	1.8	0.0	2.1	0.0	1.0	0.0	1.0
114.	2.5	3.0	2.5	2.5	0.7	2.5	0.0	1.0	0.0	0.7	0.0	0.7
115.	2.2	3.5	1.7	2.0	0.7	1.1	—	—	—	—	—	—

Notes: 53. Viking, 54. G-narrow leaved, 55. Empire, 56. Gülzower, 58. Tábor szky 60. Kubansky-44, 61. Local variety from Ják, 62. Local variety from Nagykálló, 74. *Lotus corniculatus* ssp. *corn.* var. *corn.* (Szentendre), 75. *Lotus corn.* ssp. *corn.* var. *corn.* (Tatárszentgyörgy), 100. *Lotus corniculatus* var. *dabasensis* (Dabas), 101. *Lotus corn.* ssp. *hirsutus* var. *pilosus* (Szentmártonkáta), 101a. *Lotus corn.* ssp. *hirsutus* var. *hirsutus* (Szentmártonkáta), 110. *Lotus tenuis* (procumbent Gondola f. material), 111. *Lotus tenuis* (erect Gondola f. material), 112. *Lotus tenuis* (earlier number 76.) (Tápiószele III—4—110.), 113. *Lotus tenuis* (Kunpeszér), 114. *Lotus tenuis* (Farmos), 115. *Lotus borbasii* (Hármashatárhegy)

July and 28—30th September. The material examined consisted partly of plants analysed in 1974 and partly of freshly collected wild *L. tenuis* (Kunszentmiklós, Dabas), *L. borbasii* (Hármashatárhegy) and *L. corniculatus* var. *dabasensis* (Dabas) taxa. This year two parallel series were set up: one using fresh material and one using plants dried for 48 hours at room temperature.

The examination results obtained in 1974 were as follows: the highest positive HCN reaction, both in July and September, was obtained with fresh material for all taxa, followed

Table 2

Averages of the joint HCN reaction values of leaf (shoot) and flower material from Lotus taxa on the basis of data obtained on 5th, 12th, 17th July and 6th, 13th, 19th September 1974
I = fresh material; II = material dried for 48 hours at room temperature; III = material dried for 48 hours at 110°C

Taxon	July			September		
	I.	II.	III.	I.	II.	III.
53.	5.6	5.3	2.0	5.4	5.0	0.9
54.	5.7	4.8	1.4	6.4	5.1	0.3
55.	6.4	4.5	0.6	7.2	6.0	0.6
56.	5.7	5.4	0.7	6.3	6.0	0.6
58.	5.1	4.9	0.9	6.0	3.4	0.7
60.	5.8	4.9	1.7	6.6	5.4	0.2
61.	6.7	5.0	1.5	6.4	5.5	0.45
63.	5.6	5.0	2.2	6.7	6.5	0.3
74.	5.7	5.3	1.4	6.5	6.1	0.2
75.	6.4	5.2	2.1	5.9	5.0	0.3
100.	3.6	2.8	0.6	2.0	0.7	0.0
101a.	6.1	3.0	1.4	0.0	0.1	0.0
110.	4.9	4.1	1.8	6.5	4.3	0.8
111.	5.5	5.0	2.0	6.1	5.0	0.6
112.	5.7	4.2	2.0	—	—	—
113.	2.8	2.2	1.3	1.0	0.5	0.5
114.	2.7	2.5	1.6	0.5	0.3	0.3
115.	2.8	1.8	0.9	—	—	—

Notes: 53. Viking, 54. G-narrow leaved, 55. Empire, 56. Gülzower, 58. Táborszky, 60. Kubansky-44, 61. Local variety from Ják, 62. Local variety from Nagykálló, 74. *Lotus corniculatus* ssp. *corn.* var. *corn.* (Szentendre), 75. *Lotus corn.* ssp. *corn.* var. *corn.* (Tatárszentgyörgy), 100. *Lotus corniculatus* var. *dabasensis* (Dabas), 101. *Lotus corn.* ssp. *hirsutus* var. *pilosus* (Szentmártonkáta), 101a. *Lotus corn.* ssp. *hirsutus* (Szentmártonkáta), 110. *Lotus tenuis* (procumbent Gondola f. material), 111. *Lotus tenuis* (erect Gondola f. material), 112. *Lotus tenuis* (earlier number 76.) (Tápiószele III—4—110.), 113. *Lotus tenuis* (Kunpeszér), 114. *Lotus tenuis* (Farmos), 115. *Lotus borbasii* (Hármashatárhegy)

with a slight difference — or sometimes with identical values — by the air-dried material, while the material dried at 110°C gave a very low value or even showed a negative reaction (Table 1; 0.0 = negative reaction, 0.1—0.9 = ± very low positive reaction).

In the course of the July analyses the HCN reaction was generally higher in the flower than either in the leaf or in the stem (with one or two exceptions, Table 1). The results were somewhat different in September, namely, the HCN reaction of the flowers was mostly lower. This may be connected with the fact that the analyses were made at a time when the aftercrop was in poor second flowering.

The HCN reaction of leaves and shoots was (in most taxa) higher in September than in July, though in four taxa the reaction shown in September was negative as against the low positive reaction in July (Table 1).

Table 3

HCN reaction values of Lotus taxa
I = fresh material; II = material dried for 48 hours at room temperature;
0.0 = negative reaction (−) a = leaf(+shoot); b = flower 0.1−0.9 = (±) uncertain positive reaction

Taxon	Time of measurement 1975									
	May		June				July		September	
	20th I.	22nd II.	13th I.		15th II.		24th I.	26th II.	28th I.	30th III.
	a	a	a	b	a	b	a	a	a	a
53.	5.0	3.0	7.0	4.0	4.0	3.0	6.0	4.0	5.0	4.0
54.	7.0	4.0	3.0	6.0	4.0	3.0	8.0	4.0	4.0	4.0
55.	8.0	4.0	8.0	5.0	4.0	3.0	6.0	4.0	4.0	3.0
56.	6.0	3.0	7.0	7.0	4.0	3.0	7.0	4.0	7.0	3.0
58.	5.0	2.0	7.0	5.0	4.0	2.0	7.0	4.0	7.0	4.0
60.	8.0	4.0	7.0	8.0	4.0	4.0	5.0	4.0	4.0	4.0
61.	3.0	3.0	5.0	4.0	4.0	2.0	7.0	4.0	3.0	3.0
63.	6.0	3.0	7.0	6.0	3.0	3.0	7.0	4.0	7.0	4.0
74.	7.0	3.0	8.0	5.0	4.0	3.0	8.0	4.0	7.0	4.0
75.	6.0	4.0	4.0	5.0	4.0		8.0	4.0	7.0	4.0
100.	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0
115.	0.0	0.0	0.0	1.0	0.0	0.5	0.0	0.0		
116.	0.0	0.0	0.0	1.0	0.0	0.5	0.0	0.0	0.0	0.0
117.	0.0	0.0	0.0	3.0	0.0	0.5	0.0	0.0	2.0	0.0

Notes: 53. Viking, 54. G-narrow leaved, 55. Empire, 56. Gülzower, 58. Táborszky, 60. Kubansky-44, 61. Local variety from Ják, 62. Local variety from Nagykálló, 74. *Lotus corniculatus* ssp. *corn.* var. *corn.* (Szentendre), 75. *Lotus corn.* ssp. *corn.* var. *corn.* (Tatárszentgyörgy), 100. *Lotus corniculatus* var. *dabasensis* (Dabas), 115. *Lotus borbasii* (Hármashatárhegy), 116. *Lotus tenuis* (Kunszentmiklós), 117. *Lotus tenuis* (Dabas)

The fresh leaf (+shoot) material of all taxa examined in July gave a positive reaction. The highest values were obtained in the leaves of the local variety from Ják (No. 61), and of the ssp. *hirsutus* var. *pilosus* (No. 101) (Szentmártonkáta), while the lowest ones, close to the values of the acyanogenic type, were found in the leaves and stem parts of *L. tenuis* (Kunpeszér), as well as in *L. tenuis* from Farmos and *L. borbasii* from Budapest, Hármashatárhegy. Uncertain positive or negative reaction values were given by the leaf (shoot) material of *L. corn.* ssp. *corn.* var. *dabasensis*, which suggests that it is of acyanogenic type. The leaves of the cultivated varieties gave an HCN-reaction of medium or high value, but without any great difference.

A very high positive reaction value was obtained in July in the fresh flower material of wild ssp. *hirsutus* var. *hirsutus* (No. 101a) (Szentmártonkáta) and the cultivated cv. Empire. Flowers of the two wild *L. tenuis* (Kunpeszér and Farmos) varieties and of *L. borbasii* gave a relatively low positive reaction. In a number of taxa the fresh leaf material was found to give a minimum positive value while the flowers showed very high values. For example, the HCN reaction in the leaf of *L. corniculatus* var. *dabasensis* had an average of 1.5, and

that in the flower 5.8; in the case of *L. tenuis* (Kunpeszér) the value was 1.6 in the leaf and 4.0 in the flower.

The September analyses of fresh plant parts gave a negative reaction in a number of taxa, e.g. *L. corniculatus* var. *dabasensis*, *L. corniculatus* ssp. *hirsutus* var. *hirsutus* (Szentmártonkáta) and *L. tenuis* (Kunpeszér and Farmos). At the same time, very high HCN values were obtained in the cultivars Empire and Táborszky, the local variety from Nagykálló, *L. corn.* ssp. *corn.* (Szentendre), ssp. *hirsutus* var. *pilosus*, and the procumbent cultivated *L. tenuis*. In fresh flower material the cultivar Empire gave the highest reaction followed by the cultivar Kubansky-44 and the local variety from Ják.

A remarkably low positive, in some cases even negative reaction was obtained in September with leaf and flower material dried at 110°C (Table 1).

In a number of taxa the fresh leaf material was found to give a minimum positive reaction, while the flowers gave medium values [e.g. *L. corniculatus* var. *dabasensis*, *L. tenuis* (Kunpeszér)].

Investigations made in 1975 confirmed the results of the previous year.

Analyses performed in May showed lower HCN values in the cultivars than those made in June, i.e. in plants at a purely vegetative stage (green foliage), prior to the beginning of flowering, the HCN content is lower.

The wild taxa examined gave a negative HCN reaction at any time of measurement, i.e. they proved to be acyanogenic.

Since the June analysis was made at the beginning of flowering, the data do not clearly show whether the HCN content of the flowers was higher than that of the vegetative parts, since more than half of the material examined gave lower values and a higher positive reaction was only obtained in two cases.

When analysing the leaf and dry matter of the second crop, we generally obtained higher HCN values in July than when examining the green crop in May, and — except for higher values in one or two cases — about the same as in June, at the beginning of flowering. September, on the other hand, was generally characterized by lower values.

In July the flower material of wild taxa gave a positive — though very low — HCN value (1.0—3.0), as against the negative reaction of leaf and shoot.

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USING DIFFERENT METHODS OF PROGENY TESTING FOR BREEDING VALUE ESTIMATION OF FAYOUMI COCKS

Progeny testing as one of the most efficient methods of selection is gaining ground very slowly in practice. This is due to the fact that progeny control contains a number of error sources, represents a complex breeding process and, in addition, is very expensive and lengthy. This is why solutions are being sought all over the world to increase test reliability and reduce both the costs and the period required.

The highly advanced animal breeding countries carry on progeny testing at tremendous cost, and there has been no decline in the extensive research activity carried out in this field. The establishment of any method or data for promoting the improvement of breeding value estimation by progeny testing is still an important task.

With these ideas in mind, a comparative study has been carried out to determine the most reliable and simple method of studying the hereditary transmitting capacity of cocks.

Fayoumi sires and dams were randomly mated in family pens supplied with trap nests. Each family consisted of one sire and 15 dams, and pedigree chicks were used for heritability estimates of body weight at 4 and 8 weeks of age to determine the breeding values of Fayoumi cocks. For the statistical analysis each sire used in this experiment had at least 4 dams, and each dam had at least 3 offspring. The harmonic mean of dams per sire at 4 weeks of age was 7.63 and that of offspring per dam was 6.45. For heritability estimates analysis of variance based on the model given by KING—HENDERSON (1954) was used. The breeding value of Fayoumi sires with respect to body weight was established using the following methods (ABD-ELLATIF 1968).

a) Hungarian Standard method:

$$\text{Breeding value of the sire} = \frac{X_1 - X_2}{X_2} \times 100$$

where X_1 = average production of the daughters.
X_2 = average production of contemporaries.

b) Lauprecht method:

$$ZW = \mu + h^2(X - \mu_H) + h_H^2(\mu_H - \mu)$$

where ZW = breeding value

μ = breed average
X = average of the daughters
μ_H = average production of the farm
h^2 = heritability estimate of the trait
h_H = heritability estimate of the trait in the farm

c) Siler—Vachal method:

$$ZW = 2b(y - Ay) + A$$

where y = average of the daughters
Ay = average of the contemporaries
A = breed average
b = regression coefficient.

A statistical comparison between body means was made according to the new multiple range test introduced by Duncan (STEEL—TORRIE 1960).

Table 1

Breeding value of Fayoumi sires according to the body weight of their progeny at 4 weeks of age, using different methods of estimation

Sire number	Hungarian Standard	Lauprecht	Siler–Vachal
1	26.7	123.5	233.8
2	8.6	114.5	154.6
3	−30.5	95.3	−23.6
4	− 0.9	109.8	111.0
5	−20.9	100.0	20.0
6	1.9	111.2	122.9
7	13.3	116.9	174.4
8	−2.8	108.9	103.1
9	9.5	115.0	158.6
10	1.9	111.2	122.9
11	−5.7	107.5	87.3
12	9.5	115.0	158.6
13	−9.5	105.6	61.4

The data presented in Table 1 show breeding value estimations by body weight at four weeks of age according to the three equations. The ranking of the thirteen Fayoumi sires used in the experiment according to their breeding value (Table 2) showed that changes in the sire order, established on the basis of the production of their progeny, gave almost the same trend. The classification of the sires, carried out according to the Hungarian Standard method at 4 weeks of age, was made using three grades:

Grade I: where the production of the progeny of the sire is equal to 108—127% as compared to that of the contemporaries

Grade II: where the above figure is 98—101%

Grade III: where the production of the progeny is equal to 70—95% as compared to that of the contemporaries.

According to this classification, sires 1, 7, 9, 12 and 2 were ranked in grade I, sires 6, 10, 4 and 8 in grade II, and sires 11, 13, 5 and 3 in grade III.

It was noticed that the superior sire 1 differed significantly from all the other sires, and that the differences between the sires within each category were not significant (Table 5). It was also observed that the superior sire 1 had a body weight almost twice as large as that of the last sire 3 (i.e. 133 as against 73 grams). This difference may be a reflection of the genetic variation, since all the progenies were brooded under the same environmental conditions. However, no selection had been made before on this group. This genetic variation makes it possible to carry out selection for body weight according to progeny testing.

At 8 weeks of age it was clear that the ranking of the sires was the same according to the different equations used and the classification mentioned before (Tables 3, 4; Figs 1, 2, 3). It was found that sires 1, 12, 2, 4 and 7 were ranked in grade I, sires 9, 6, 10 and 8 in grade II and sires 11, 5, 13 and 3 in grade III. It was of interest to notice that grade I included

Table 2

Variation of the ranking of sires by the body weight of their progeny at 4 weeks of age, according to different methods

Sire number	Sire ranking according to		
	Hungarian Standard	Lauprecht	Siler–Vachal
1	I	I	I
2	V	V	V
3	XIII	XIII	XIII
4	VIII	VIII	VIII
5	XII	XII	XII
6	VI	VI	VI
7	II	II	II
8	IX	IX	IX
9	III	III	III
10	VII	VII	VII
11	X	X	X
12	IV	IV	IV
13	XI	XI	XI

Table 3

Breeding value of Fayoumi sires according to the body weight of their progeny at 8 weeks of age, using different methods of estimation

Sire number	Hungarian Standard	Lauprecht	Siler–Vachal
1	26.4	238.6	428.9
2	7.8	219.5	282.4
3	−15.4	194.9	92.3
4	4.9	216.7	258.6
5	−9.2	201.6	143.8
6	−2.4	208.9	199.2
7	3.4	215.1	246.7
8	−4.9	206.1	179.4
9	1.9	213.4	234.8
10	−3.4	207.8	191.8
11	−6.3	204.4	167.5
12	9.3	221.2	294.2
13	−11.1	199.4	127.9

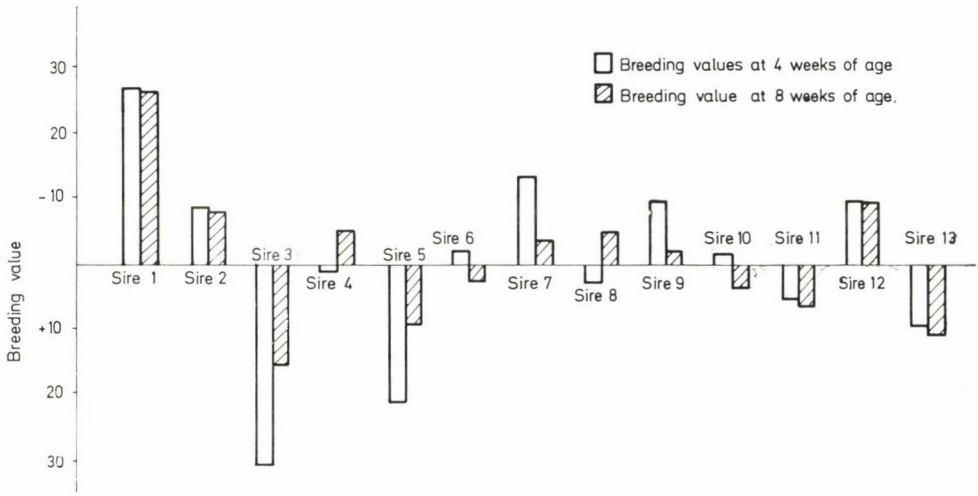

Fig. 1. Breeding value of sires by body weight at 4 and 8 weeks of age according to the Hungarian Standard method

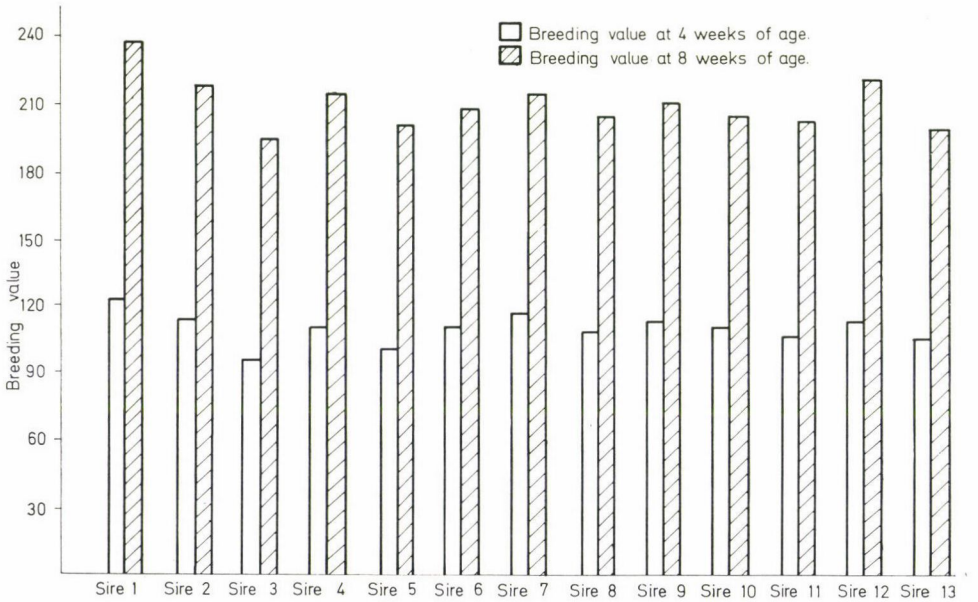

Fig. 2. Breeding value of sires by body weight at 4 and 8 weeks of age according to the Lauprecht method

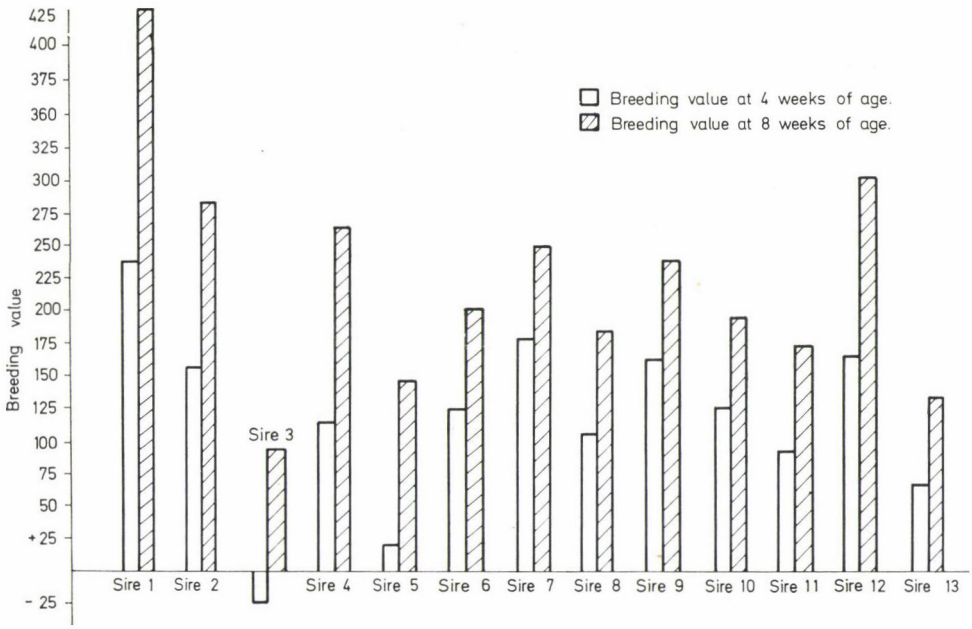

Fig. 3. Breeding value of sires by body weight at 4 and 8 weeks of age according to the Siler—Vachal method

Table 4

Variation of the ranking of sires by the body weight of their progeny at 8 weeks of age, according to different methods

Sire number	Sire ranking according to		
	Hungarian Standard	Lauprecht	Siler–Vachal
1	I	I	I
2	III	III	III
3	XIII	XIII	XIII
4	IV	IV	IV
5	XI	XI	XI
6	VII	VII	VII
7	V	V	V
8	IX	IX	IX
9	VI	VI	VI
10	VIII	VIII	VIII
11	X	X	X
12	II	II	II
13	XII	XII	XII

Table 5

Comparisons between every two means of body weight at 4 and 8 weeks of age by the new multiple range test introduced by Duncan

	At 4 weeks of age												
Sires	1	7	9	12	2	6	10	4	8	11	12	5	3
Means	133	*119*	*115*	*115*	*114*	*107*	*107*	*104*	*102*	*99*	95	*83*	*73*
	At 8 weeks of age												
Sires	1	12	2	4	7	9	6	10	8	11	5	13	3
Means	254	*223*	*220*	*215*	*212*	*209*	*201*	*199*	*196*	*193*	*188*	*184*	176

Note: Any two means not underscored by the same line are significantly different at the 5% level

sires 1, 7, 12 and 2 at both ages, 4 and 8 weeks, while grade III contained the same sires in both cases.

These results indicate that it is possible to apply any one of the three equations used in the experiment to predict the breeding value of cocks according to early information on their progeny.

*

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CHEMICAL INDUCTION OF MALE STERILITY IN SUNFLOWER

The difficulties to be overcome in making use of the heterosis effect vary at present with the plant species. It is probable, therefore, that economically efficient solutions will be arrived at in different ways. In the case of strictly xenogamous plants, like the sunflower, no practical application of the heterosis effect can be reckoned with without the castration of the bisexual flowers. Fortunately, genic, cytoplasmic and self-incompatible methods offer

possibilities which, though more time-consuming, can already be utilized. Since the cytoplasmic transmission of pollen sterility, and the detection and introduction into high productivity inbred lines of pollen fertility restorer factors are for several reasons complicated and time-consuming, some other solution must definitely be found.

Few authors have dealt as yet with the chemical induction of male sterility in sunflower. Although attempts to influence the sex ratios in certain plants with unisexual flowers have been successful, adaptable results can be obtained from these experiments only in a very general sense (LAIBACH—KRIBBEN 1950, WITTWER—HILLYER 1954). This is demonstrated convincingly by the summaries of WITTWER—BUKOVAC (1958), BÜNSOW (1958) JUNG—PFAFF (1958) and KNAPP (1958), and by the maleic hydrazide treatment applied by NAYLOR (1950), DENISEN—HABER (1950) and MOORE (1950) in maize, and the sodium α-β-dichloroisobutyrate treatments used by EATON (1957) in cotton and by BUTTERFASS (1960) in sugar-beet, which were only partially successful, since SCHUSTER (1961, 1963, 1969) made abortive attempts with the above chemicals as well as with α-naphthyl-acetic acid (NAA), β-indole-acetic acid (IAA) and 2,4-dichloro-phenoxy-acetic acid (2,4-D) in sunflower. This may be caused by the low reproducibility of the experimental results. Such unreliability is unacceptable even if the method is to be introduced into the crossing technique of breeding. The direct use of these materials is thus only of theoretical importance at present, though later they may well be taken into consideration in a possible combined experimental methodology. KIERMAYER (1959) found the tri-iodo-benzoic acid treatment to cause androeceum reduction in the sunflower, but his results require further corroboration.

Much more promising results are reported by SCHUSTER (1961, 1963, 1969) and KLIMOV (1971) in experiments performed with gibberellin in sunflower, though the treatments applied to maize by NELSON—ROSSMANN (1958) and the reproduction studies made by SCHUSTER (1961) himself make them less unambiguous. According to BARABÁS (1976) the application of this treatment has no future, despite the fact that PALEY—ASPINALL (1958) and SCHMALZ (1960) report the successfulness of gibberellin treatment on barley.

From the above it may be concluded that further chemicals and methods should be tested, and it is also probable that the solution will be different for each species. The aim of our experiments was to induce male sterility in sunflowers by means of hormones, and to study the dependence of this mechanism on environmental factors, in the course of which an answer may be forthcoming to the question of reproducibility and to other morpho-physiological problems arising after the treatment.

In the outdoor trials set up at the Kiszombor station of the Cereal Research Institute a dwarf inbred line of the Soviet sunflower variety WNIIMK 6540 was used. The seed was obtained from the 1974 propagation. Sowing was carried out on 9th May 1975 at a spacing of 60×60 cm. The treatments were scheduled for the 33rd day after sowing and the subsequent 3×2 days; of the possible methods of application those chosen were surface treatment on the growth tip of the shoot and on the leaves, and injection into the stalk. In the first year natural plant hormones were used: 0.033, 0.016 and 0.0033% aqueous solutions of gibberellic acid (GA_3) and 0.01, 0.005 and 0.001% aqueous solutions of indole-acetic acid (IAA). Each of the 36 combinations was tested in a plot with 16 plants. Besides the pollen production we studied the extent of full sterility and self-incompatibility as well as the effects of these chemicals on the vegetation period, plant height, diameter of head, size of leaf and thousand-achene-weight. The term parital protogynia refers not to the flower but to the capitulum as a whole. (Either only the outer or only the inner circles are fertile.) The experiments also enabled us to determine the changes occurring in the endogenous IAA and GA_3 contents following the treatments, the results of which will be published elsewhere.

As shown by the data of Table 1 none of the concentrations of IES produced any effect, that is, the differentiation of the androeceum was found to be normal. This was proved

Table 1

Relationship between IAA treatment and sex ratio in sunflower

Method	Time of treatment (month, day)	Concentration, %	Beginning of flowering		Protandria, %	Partial protogynia, %	Full protogynia, %	Number of achenes per capitulum	Empty achenes %	Number of achenes per capitulum	Empty achenes, %	Thousand-achene-weight, g	Thousand-achene-weight, g	Note
			extremes (day)	average (day)				I		II		I	II	
SGTS	June 11th	0.01	13—19	17.5	100	—	—	1047	2.9	414	12.5	58.3	65.6	
SGTS	June 11th	0.005	13—20	17.2	100	—	—	1112	1.4	587	72.9	64.0	95.6	
SGTS	June 11th	0.001	14—19	17.6	100	—	—	999	17.4	909	68.4	80.0	92.6	
IN	June 11th	0.01	17—20	18.1	100	—	—	1252	9.3	660	74.5	68.6	90.1	
IN	June 11th	0.005	17—21	19.0	100	—	—	911	9.1	711	47.2	67.7	91.9	
IN	June 13th	0.001	14—19	17.2	100	—	—	695	—	738	49.5	72.0	89.6	
SGTS	June 13th	0.01	16—22	19.0	100	—	—	951	3.9	807	68.2	86.0	99.3	
SGTS	June 13th	0.005	13—21	18.8	100	—	—	710	0.6	863	84.7	78.7	89.8	
SGTS	June 13th	0.001	14—18	16.4	100	—	—	1134	10.6	871	61.4	79.5	85.0	
LS	June 13th	0.01	13—22	17.3	100	—	—	1153	—	917	51.6	71.9	78.1	
LS	June 13th	0.005	15—20	18.0	100	—	—	1333	1.2	1565	72.5	63.5	82.5	
LS	June 13th	0.001	15—19	16.5	100	—	—	1043	1.7	1062	64.0	71.9	70.5	
SGTS	June 15th	0.01	17—21	19.5	100	—	—	1120	14.0	—	—	78.0	—	
SGTS	June 15th	0.005	19—20	19.0	100	—	—	—	—	256	3.1	—	53.8	
SGTS	June 15th	0.001	16—22	19.1	100	—	—	1481	68.3	646	71.2	107.3	62.1	
SGTS	June 17th	0.01	13—19	16.9	100	—	—	843	13.8	999	68.2	77.5	90.0	
SGTS	June 17th	0.005	17—20	17.9	100	—	—	1145	23.8	787	80.2	86.5	88.8	
SGTS	June 17th	0.001	15—22	17.4	100	—	—	—	—	544	62.5	—	86.9	

Signs and abbreviations: SGTS: shoot growth tip surface treatment
IN: injection
LS: leaf surface treatment
I: cross pollination
II: self-pollination

Table 2

Relationship between gibberellin treatment and sex ratio in sunflower

Method	Time of treatment (month, day)	Concentration %	Beginning of flowering		Protandria %	Partial	Full	Number of achenes per capitulum	Empty achenes, %	Thousand-achene-weight, g	Number of achenes per capitulum	Empty achenes, %	Thousand-achene-weight, g
			extremes (day)	average (day)		krotogynia, %		I			II		
SGTS	June 11th	0.033	11—15	13.0	—	33.0	67.0	283	4.2	64.0	—	—	—
SGTS	June 11th	0.016	13—18	14.5	57.1	14.2	28.7	330	0.9	53.5	—	—	—
SGTS	June 11th	0.0033	13—18	14.7	70.0	20.0	10.0	980	—	63.7	—	—	—
IN	June 11th	0.033	10—13	12.2	—	37.5	62.5	225	—	48.6	—	—	—
IN	June 11th	0.016	13—19	16.6	33.0	67.0	—	288	8.6	65.5	—	—	—
IN	June 11th	0.0033	11—19	14.6	87.5	—	12.5	523	5.2	63.7	—	—	—
SGTS	June 13th	0.033	13—17	14.8	—	60.0	40.0	225	—	62.3	—	—	—
SGTS	June 13th	0.016	11—14	12.9	22.3	33.3	44.4	295	31.0	76.2	—	—	—
SGTS	June 13th	0.0033	8—16	12.1	77.7	22.3	—	869	1.2	68.8	—	—	—
LS	June 13th	0.033	11—15	12.7	8.4	58.2	33.4	252	7.1	68.8	—	—	—
LS	June 13th	0.016	9—18	13.7	45.5	18.2	36.3	353	—	73.7	183	64.5	98.0
LS	June 13th	0.0033	13—18	15.7	91.0	9.0	—	930	20.8	67.5	—	—	—
SGTS	June 15th	0.033	12—18	15.7	—	—	100.0	147	3.4	63.0	—	—	—
SGTS	June 15th	0.016	15—20	15.6	—	25.0	75.0	322	2.8	41.8	—	—	—
SGTS	June 15th	0.0033	12—18	15.2	75.0	12.5	12.5	716	1.3	57.0	872	81.0	54.3
SGTS	June 17th	0.033	12—18	13.5	—	18.0	82.0	370	15.6	63.4	—	—	—
SGTS	June 17th	0.016	9—16	12.8	9.2	27.2	63.9	458	19.2	67.7	—	—	—
SGTS	June 17th	0.0033	10—19	14.7	63.6	18.2	18.2	1107	20.5	56.1	1776	98.5	118.0
Control			16—19	17.0	100.0	—	—	1260	13.5	78.6	—	—	—

Note: in protogynous type flowers no pollen formation was found.

Table 3

Effects of indole-3-acetic acid and gibberellin (GA_3) on plant height, head diameter and leaf size

Chemical	Plant height (cm)	Head diameter (cm)	Leaf width (cm)
IAA	93.6	23.9	24.3
GA_3	139.0	14.2	12.6
Control	94.6	21.3	19.1

by the fact that in the presence of pollen from another plant the number of achenes per capitulum remained at the level of the control; the occasional lower values were due to individual deviations. It should be added that we found a simultaneous increase in thousand-achene-weight, which also affected the total yield. In the case of strict self-pollination seeds were absent from most of the achenes developing in the capitulum, as proved by the high percentage of empty achenes. As to the other morphophysiological effects of IAA (Table 3) we recorded the beginning of flowering (on a plot average), and the final plant height, head diameter and leaf width, irrespective of the concentration and method of treatment.

As regards the properties mentioned — except for the plant height — we found somewhat increasing values expressed in a delay of about 1—2 days in flowering and in the larger diameters of the capitulum and leaf. Apart from this, the yellowing of leaves at the time of ripening sets in later than in the control plants.

Much more favourable results are reflected by the data of Table 2. In spite of the unfavourable rainy weather, the surface treatment of the growth tip of the shoot with a 0.033 per cent aqueous solution of GA_3 on the 37th day after sowing resulted in 100% male sterility. The best result with the 0.016% concentration was also obtained at this time. With other times and methods of treatment the efficiency of GA_3 application decreased. On each occasion the highest concentration applied gave the most favourable full protogynia percentage. On the other hand, it can be regarded as an unfavourable phenomenon that the efficiency of the treatment showed a strictly negative correlation with the number of achene per capitulum, which according to the data in Table 3 can be explained by a decrease of about 70% in the size of the head compared to the control. The percentage of empty achenes was substantially lower than what was expected. At low concentrations of GA_3, where protandric plants occurred in large numbers, self-pollination was also carried out. The result was a very strong fertilization disorder.

As for the other properties, gibberellic acid increased the final length of the stalk by some 30%, but decreased the width of the leaf (length unchanged) and the diameter of the capitulum, and resulted in flowering being 4—5 days earlier.

From the above data it can be seen that the induction of male sterility is a function not only of the nature of the chemicals applied but also of the concentration and the time of treatment.

This latter represents the greatest difficulty in outdoor and mass application, since it is related to the uniformity of the population, which is very difficult to ensure at the desired level under outdoor conditions even using inbred material. Another unfavourable phenomenon connected to this is the negative correlation between the achene yield and the protogynia percentage at the population level. There was deliberately no mention made of the manner of treatment since it is closely related to the concentration and with the amount of material which the plant can absorb in a short time.

Here reference must be made to an earlier work in which we studied the effect of tha given hormone treatments on the endogenous auxin and gibberellin levels in the sunflower. The changes in the auxin and gibberellin contents mostly showed a negative correlation, but the exceptions and the apparently contradictory literary data (POZSÁR 1964) prove that the concentrations is of decisive importance for the rearrangement of biochemical processes within the cell. In the present experiments the "threshold value of total gibberellin" necessary to induce male sterility was ensured by the method of treatment and the concentration. This is shown by the differences in effectiveness between the applied methods, which ensure the right time and quantity of material uptake in a different measure. Thus the gibberellin may inhibit or, in certain cases, stimulate the process of auxin decomposition. It is also probable that the decisive factor is the intensive metabolism, that quickly eliminates the results of exogenous influences, rather than the constantly higher endogenous gibberellin and lower auxin content. This is clear from a comparison of the results of concentrations and treatment times. Thus we may assume that either directly or indirectly the gibberellin plays the role of a fairly specific inductor in the complicated process of flower differentiation.

Although the changes in the endogenous indole-acetic acid and gibberellin levels show different tendencies in the IAA-treated plants than in those treated with gibberellin, the possibility of future IAA application is not unequivocally excluded. In order to discover the relationships higher concentrations will also be tested in the future.

In spite of the current difficulties the method described can be recommended to facilitate the implementation of crossing experiments. As regards the production of sunflower hybrid seed, cross-pollination should be guaranteed and an acceptable yield ensured. A basic condition for this is the establishment of a genetically stabilized, uniformly germinating and developing stand and the discovery of cheap, prolonged action, readily available and transportable chemicals. These are necessary because of the protracted flowering period, and to reduce to a minimum the influence of unfavourable weather conditions. From the point of view of ensuring an adequate quantity of hybrid seed production, it is not certain that the use of high concentrations causing full protogynia, together with post-treatments to compensate for the negative effects, is the right solution. It may be questioned whether it is at all possible to make acceptable "corrections" to changes affecting the whole habit after such treatments. The high number of achenes per capitulum and the percentage of empty achenes obtained in the course of self-pollinating fertile plants treated with low concentrations seem very promising.

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INTERLINK IN MINERAL COMPOSITION BETWEEN HOST AND PARASITE DURING CUSCUTA INFECTION

Heterotrophic plants like *Cuscuta* obtain their mineral requirements from the host plant along with their organic food (THOMSON 1925). These minerals may either enter into the body composition of the parasite (e.g. Mg, S), play an important role in energy transfer (e.g. P), act as coenzymes (e.g. Fe, Mo, S) or activate several enzyme systems (e.g. Mn). The role of some of the elements, such as potassium and calcium, is not yet fully known (BONNER 1950, STEWARD 1959), although they are undoubtedly essential for flowering plants (MEYER—ANDERSON 1952). A few studies on the chemical composition of *Cuscuta* have been carried out by various workers, such as AGARWAL—DUTT (1935), GOPINATH *et al.* (1962), JAIN—MISHRA (1963) and SUBRAMANIAN—NAIR (1963). However, in the literature no reference has been found to a relationship in mineral composition between the parasite and the host except for that with phosphates during infections by *Cuscuta* (SINGH *et al.* 1963) and *Loranthus* (PRAKASH *et al.* 1967).

The present investigation was undertaken to study the *Cuscuta* — host relationship with respect to mineral composition. The distribution of minerals in the host and the parasite forms the first phase of the present study. The study of ratios of different ions, such as Fe/Mn, Na/K and P/S, have revealed many ionic interactions (CURTIS—CLARK 1950). A study of the ratios of Fe/Mn, Ca/Mn, Ca/Fe, Ca/K, Mn/Mo, P/Mo and P/S forms the second phase of this investigation.

Specimens of *Cuscuta reflexa* growing on twelve hosts (viz. *Ficus glomerata* Roxb., *Ficus carica* L., *Carissa carandas* L., *Citrus aurantifolia* L., *Inga dulcis* Will., *Duranta pulmieri* Jacq., *Ricinus communis* L., *Annona squamosa* L., *Aegle marmelos* Corr., *Ixora perviflora* Vahl., *Psidium guayava* L., *Salmalia malabarica* Sch. & Endl.) were collected at the

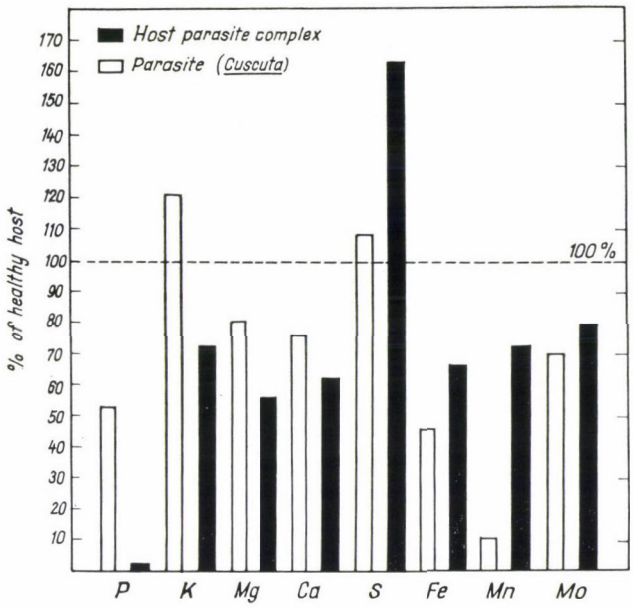

Fig. 1. Overall mineral composition of host–parasite complex and parasite (mean of twelve hosts) as percentage of host values

preflowering stage of the parasite (August—September). Corresponding samples of the host and the host–parasite complex were also collected at the same time for the analysis of mineral composition. By host–parasite complex we mean the gall region of the host where the parasite has introduced its haustoria, but excluding the parasite stem or filament.

Soon after the samples were taken from the field, they were brought to the laboratory oven-dried and the analysis of mineral composition was carried out according to methods described in the standard textbooks, i.e. for phosphorus after KUTTNER—LICHTENSTEIN (1932), for potassium, magnesium, calcium and sulphur after WARD—JOHNSTON (1960), for iron, manganese and molybdenum after SNELL—SNELL (1959) (carried out after wet ashing with perchloric acid by the colorimetric method). The correlation values of hosts and parasite were studied. The results are given as percentages.

Figure 1 reveals that except for phosphorus, potassium and sulphur, the rest of the elements under study (Mg, Ca, Fe, Mn and Mo) were found in higher quantities in the host tissues than in the parasite. The quantities of the minerals P, K and S accumulated in the parasite were in the sequence given. The mineral composition of the host–parasite complex showed a lower value for P, K, Mg and Ca than that of the parasite, but this was not the case for sulphur, iron and manganese. The molybdenum content was almost the same in the parasite and in the host–parasite complex, which mainly represents the parasitized host tissue. The accumulation of sulphur in the host–parasite complex is most striking and the value surpasses the sulphur values of both the host and the parasite.

Correlation studies (Fig. 2) have revealed a positive correlation between the mineral composition of the host and the parasite. Studies of mineral ratios (Fig. 3) have shown good correlations for Fe/Mn, P/Mo and P/S between the host and the parasite. This indicates the probable role of these elements in the nitrogen metabolism and oxidative process of the parasite.

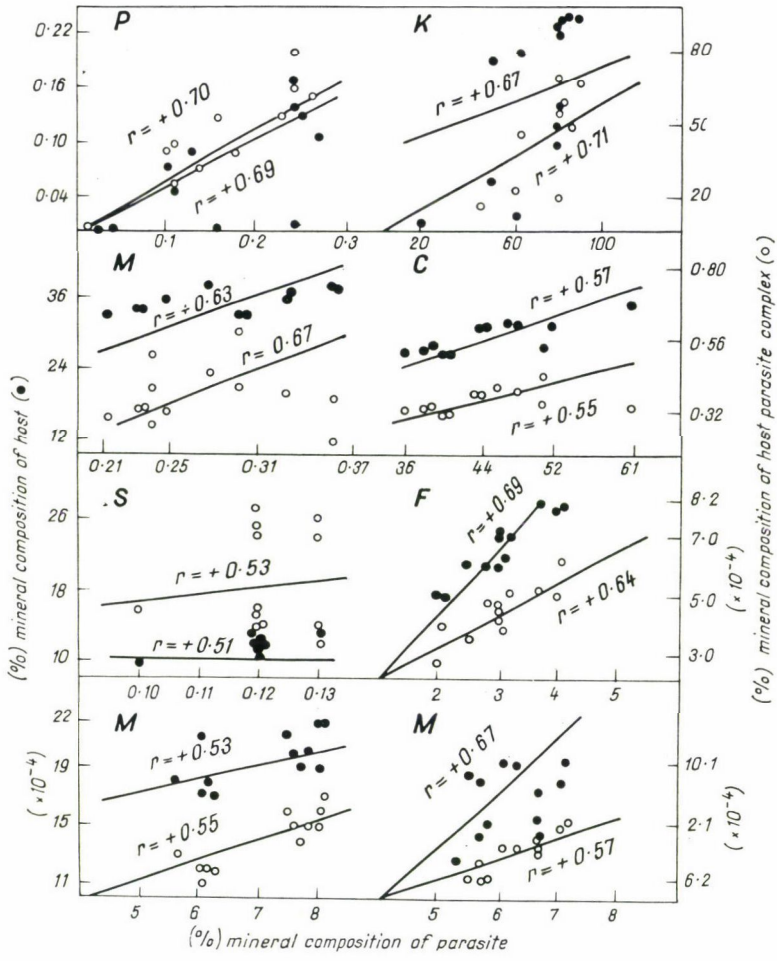

Fig. 2. Correlation between the mineral composition of host and host–parasite complex against the mineral composition of the parasite

The mineral composition of plants largely depends on the availability of inorganic nutrients and the physiological capacity of the plants to absorb them (TRUOG 1961). This gives rise to the idea of foliar diagnosis for judging the nutrient status of the soil (RUSSELL—RUSSELL 1961). Since the host of the *Cuscuta* is the substrata of the parasite, the mineral composition of the parasite, as anticipated, varied with the availability of inorganic nutrients from the host tissue. It must be borne in mind that the host is a living substrate and naturally the elements did not all behave identically (PREVOT—OLLAGNIER 1957).

Phosphorus, potassium and sulphur are accumulated in the parasite to a much higher degree compared to other elements. The requirement of magnesium for the parasite is lower than for the host; this could be related to the scanty amount of chlorophyll present in the parasite (PATTEE *et al.*, 1965). However, vestigial chlorophyll has a higher magnesium requirement than the host–parasite complex, which has very little chlorophyllous tissue. The parasite has a lesser demand for calcium than the host.

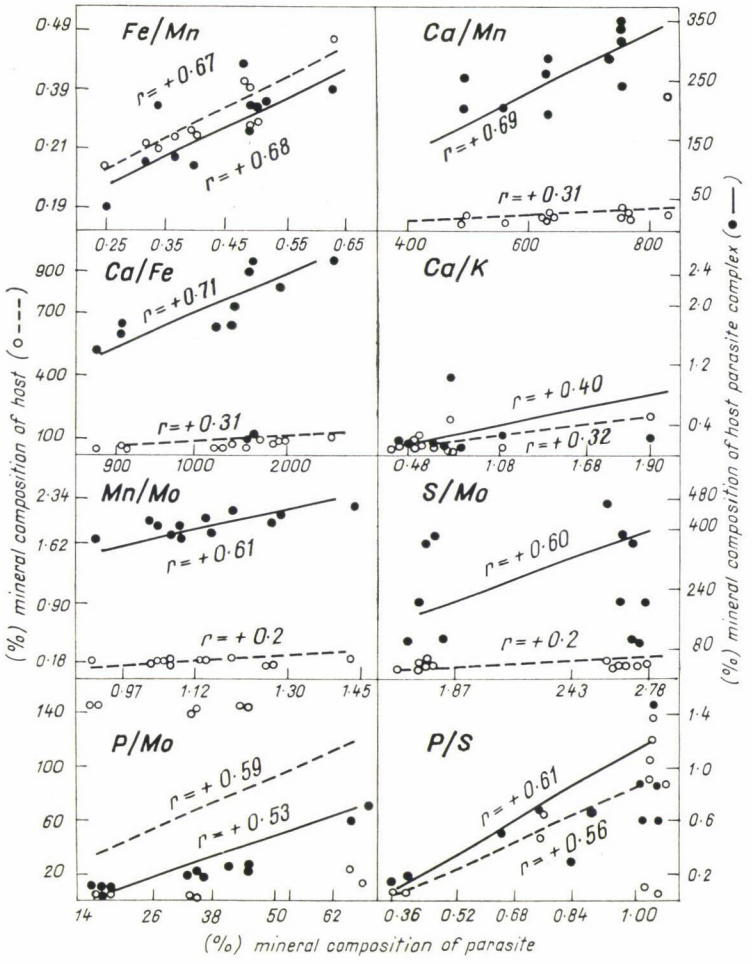

Fig. 3. Correlation between the mineral ratios of the host and host–parasite complex against the parasite

The low level of manganese and molybdenum in the parasite could indicate that the parasite obtains nitrogen from the host in an organic form and that the intermediate reduction processes are perhaps totally bypassed. The positive correlations for Fe/Mn, P/Mo and P/S between the host and the parasite suggest that the most important role of the minerals in the physiology of the parasite is through energy transfer, and through enzyme reactions involving nitrate reduction or oxidative processes. Furthermore, the rapid growth of the parasite is directly related to a high phosphorus uptake.

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FIVE YEARS RESULTS OF INVESTIGATIONS INTO POWDERY MILDEW IN WHEAT AT MARTONVÁSÁR (1971—1975). II. ROLE OF VARIETY IN RACE COMPOSITION

The composition of the pathogenic race population depends on numerous factors of which the major ones are: resistance of commercially grown varieties, virulence of the race, climatic factors (LELLEY 1959, BEKE 1965, VAN DER PLANK 1968, GESELE 1969, SZUNICS—SZUNICS 1974). Starting from this basis we carried out investigations to find out which powdery mildew races attacked the commercial wheat varieties, what the difference between the varieties was, and what the explanation of Kavkaz and Avrora having "lost" their resistance was.

Powdery mildew was collected from different varieties sown on the trial area. In identifying the races the method of NOVER (1957) was used.

Table 1 shows the percentage distribution of races isolated from varieties grown on larger areas in the past years; 27 races have been isolated from Bezostaya 1. This variety is susceptible to practically all races, as proved by the fact that the occurrence percentages

Table 1

Percentage distribution of wheat powdery mildew races isolated from different varieties (1970/71—1974/75)

Races	Varieties					
	Bezostaya 1	Fertődi 293	Mironovskaya 808	Rannyaya 12	Avrora	Kavkaz
0	8.99	8.47	7.02	5.45		
1	1.12					
2	3.38	3.39	3.51	3.64	5.66	12.96
3	4.49	10.17	1.75	9.09	1.89	
4	11.23	11.86	8.78	14.55	26.41	12.96
5		1.69	3.51		1.89	
7	3.38	6.78	7.02	3.64		
8				1.82		
9	4.49	5.08	10.53	9.09	9.43	18.53
10	1.12				3.77	3.70
13	8.99	8.47	1.75	3.64		
14	6.74	6.78	8.78	7.27	3.77	
15	3.38		1.75	1.82		
16	2.25	5.08				
17	1.12			1.82		
18	2.25	3.39		5.45		1.85
19	1.12	1.69	1.75			
21	1.12	1.69		1.82		
22	1.12					
24					1.89	
26	7.87	8.47	19.30	5.45	22.64	11.11
27	4.49					9.26
29		1.70				
30			1.75	1.82		1.85
31	1.12	1.70	1.75	5.45		
32	5.62	1.70	1.75	1.82	7.55	7.41
35	2.25		1.75			1.85
40		1.70	3.51			
43		1.70				
44	1.12	1.70				1.85
46	2.25	1.70	1.75		1.89	
47	2.25	3.39				
48	1.12		1.75	3.64	1.89	
52	5.62		10.54	12.72	11.32	16.67
53		1.70				
Pure culture produced (n)	89	59	57	55	53	54
Isolated races (n)	27	23	20	19	13	12

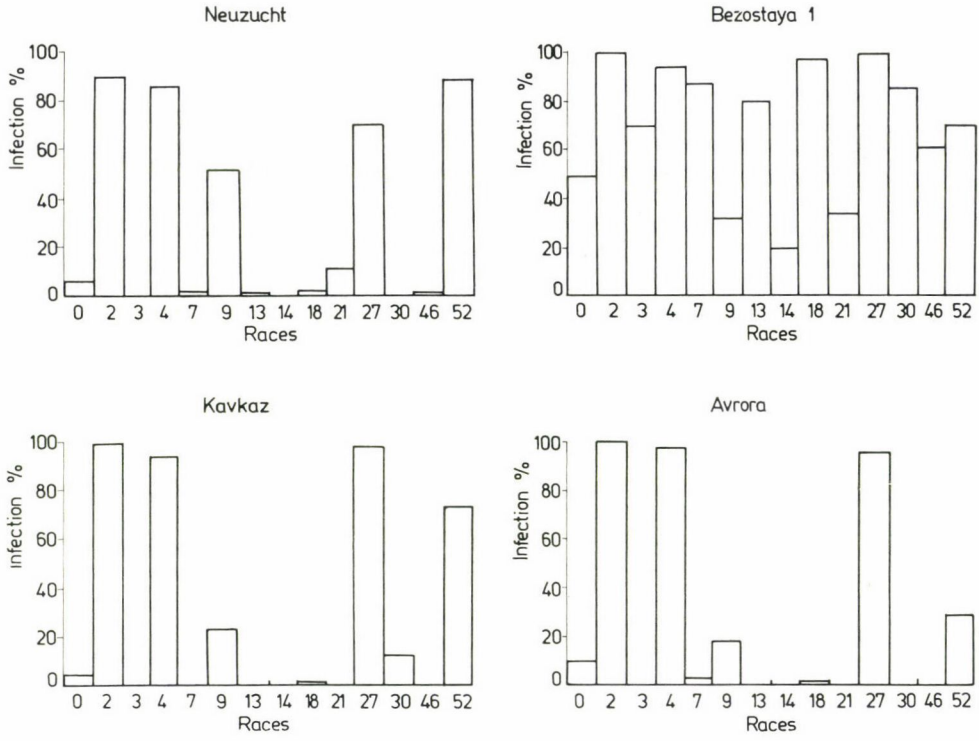

Fig. 1. Infection of the varieties Neuzucht, Bezostaya 1, Kavkaz and Avrora by various races of powdery mildew

of the races are similar, with the exception of races 0, 4 and 13. It is on this variety that pure cultures are propagated and the races maintained.

In the powdery mildew population collected from the variety Fertődi 293 a total of 21 races have been identified; with the exception of races 0, 3, 13 and 26 they show the same frequency of occurrence. Twenty races have been isolated from Mironovskaya 808; the more frequent ones are: 9, 24 and 52. Of the 19 races isolated from Rannyaya 12, Nos 3, 4, 9 and 52 are dominant. While the total number of races isolated from Avrora and Kavkaz is lower, the number of those showing a higher virulence is larger.

This also shows that the resistance of the host (variety) is not a general feature but one effective against certain races of the pathogen. The same opinion is held by STAKMAN—HARRAR (1957) and KIRÁLY (1969). When studying the host–parasite relation the relationship of two living organisms under given climatic, soil and production technology conditions is always taken into consideration. The factors mentioned may influence the resistance of the host plant and the aggressiveness of the pathogen. Both host and pathogen have definite genetic features, among others variability. Consequently, the introduction of a new resistant variety in commercial production may result not only in the decrease of the prevalent races, but also, in response to the new conditions, existing races which have so far occurred in low percentages (sporadic races) may multiply, while entirely new races may also come into existence. As these increase in numbers, the earlier resistant variety will become susceptible. That is what has happened to the varieties Kavkaz and Avrora in Hungary.

As is known, in 1968, when Kavkaz and Avrora were introduced, they were resistant to powdery mildew. These varieties were produced by crossing (Neuzucht × Bezostaya 4) with Bezostaya 1 (LUKYANENKO 1967). They seem to have inherited their resistance from Neuzucht. This theory is confirmed by the similarity of their susceptibility to certain races and resistance to others (Fig. 1).

Several years after the introduction some Kavkaz and Avrora plants became infected while others remained resistant, that is, the two varieties were no longer uniformly resistant. In the subsequent years the resistant plants completely disappeared, and the whole stand was uniformly infected, although this occurred 10—14 days later than in the other varieties. By now even this difference has ceased and these varieties too are susceptible.

The "loss" of resistance has been explained by our experiments. The race composition of the pathogen depends in the first place on the susceptibility of the varieties grown. Since until 1970 Bezostaya 1 was grown on nearly 80% of the wheat area in Hungary, and this variety is susceptible to all races of wheat powdery mildew, the races in the population therefore had identical chances. With the introduction of Kavkaz and Avrora the situation has changed. As seen in Fig. 1 these varieties were resistant to certain races and became infected by others. The latter, however, represented only a minor part of the pathogen population, so the precondition of biological plant protection could be developed, since the multiplication of races pathogenic for these varieties took time. But as the sowing area of Kavkaz and Avrora increased the pathogen was able to spread at a faster rate.

Kavkaz and Avrora have a vertical resistance. Of the 38 races isolated in Hungary 12 were isolated from Kavkaz. The more frequent ones are: 2, 4, 9, 26, 27 and 52. Of the race virulent to Kavkaz races 4, 26 and 52 have primarily spread. Thus, Kavkaz and Avrora are mainly infected because of their susceptibility to races 4 and 26, which have been known for some time, and to 52, a recently isolated race.

Figure 2 shows the sowing areas of Kavkaz and Avrora and the distribution of races isolated from them. With the increase of the sowing area of these two varieties the races virulent to them have also grown in number. In 1971 the races isolated from Kavkaz made up 38% of the race population; their proportion grew to 84.7% by 1975. In the same period the joint sowing area of Kavkaz and Avrora increased from 1 to 48%.

It is still more interesting to look at races 4, 26 and 52. These three races represented 4% of the powdery mildew population at Martonvásár in 1971, 23% in 1972, 29% in 1973, 45.5% in 1974 and 55% in 1975.

With the spreading of races virulent to resistant varieties, the hitherto resistant varieties become susceptible, which results in the need to produce new resistant varieties, and to introduce them into commercial production. Thus, breeding for resistance is a permanent process. Its success depends on various conditions, one of which is the proper choice and utilization of the source of resistance.

The task of breeding for resistance is to produce, select and propagate genotypes resistant to diseases and outstandingly good as regards their economic properties. In general, the best varieties are used for crossing. Good resistance sources are small in number; therefore crossing is often carried out repeatedly with the same donor. Consequently, the new varieties may be related to one another. As an example we can mention Bezostaya 1, which is grown even now on a relatively large area in Hungary. With regards to their share in the total wheat area, this is followed by Kavkaz and Avrora. The male parent of the two latter varieties was Bezostaya 1. The four new Martonvásár wheat varieties recently certified also had Bezostaya 1 as one of their parents. This leads to genetic uniformity in the commercially grown varieties. Due to their genetic similarity (uniform susceptibility) they promote the rapid multiplication of certain pathogens. In Hungary the fact that wheat powdery mildew has gained ground to such an extent can be brought into connection with the increased sowing

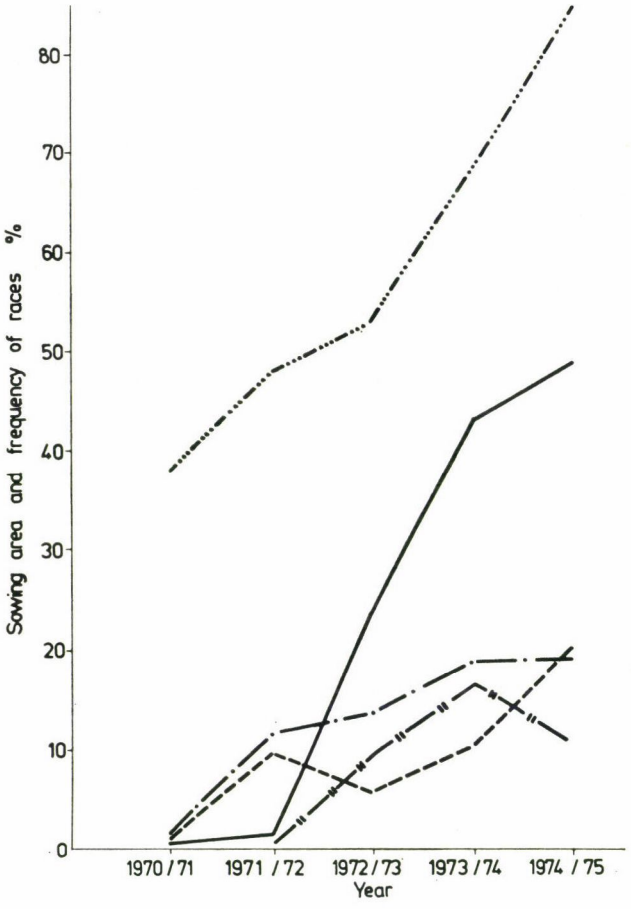

Fig. 2. Sowing area of Kavkaz and Avrora and distribution of races isolated from them (——— sowing area of Kavkáz and Avrora, ——···—— total races isolated from Kavkaz, — · — race 4, - - - - - - race 26, — · · — race 52)

area of Bezostaya 1. The introduction of Kavkaz and Avrora has resulted in the development and multiplication of new races. Therefore the breeders must make a supreme effort to utilize resistance sources with different genotypes. This is why we agree with the statement made by HAGBERG (1968) that the sources of resistance in our possession must be used with great care in order to prevent the evolution of new races of pathogen and increase the degree of resistance.

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VARIABILITY AND HERITABILITY OF EARLY GROWTH VIGOUR AND ITS ASSOCIATION WITH FORAGE AND GRAIN YIELDS IN BAJRA PENNISETUM TYPHOIDES (BURM F.) S & H

Bajra is an excellent forage crop for low fertility and low rainfall areas. A substantial variation in forage yield was observed by GUPTA—ATHWAL (1966) and GUPTA—NANDA (1971). However, the desired success in forage improvement through direct selection for this character could be achieved because of its low heritability values (BURTON 1959, GUPTA—NANDA 1971). The possibility of improvement in forage yield through selection for any one of its components, namely tiller number, leaf number, leaf size and plant height is also doubtful, as their association with forage yield was not consistent in different groups of collections (GUPTA—NANDA 1971). Thus there is a need to find a suitable selection criterion which may be used to improve forage yield.

Early growth vigour has been reported to be positively associated with forage yield in other crops (TWAMLEY 1973) but there is no information regarding its value in bajra forage improvement. A study was therefore conducted to discover the variability and heritability of early growth vigour and its association with forage yield. Grain yield was included in this study to explore the possibility of producing a dual-purpose variety, that is for forage as well as grain. Estimates of variability and heritability of forage yield and grain yield were also obtained, because such information is useful in planning a breeding programme. Days to flowering, when the forage crop was harvested, may affect the forage yield. Therefore this character was also studied.

The material of the study included 12 male fertile lines selected at random from those which performed well under local conditions during the 1971 and 1972 seasons, 2 male sterile lines (Tift.23A and Tift.23D_2A) and 15 F_1 crosses of male lines with Tift.23A and/or Tift.23D_2A (Table 1). In addition to these, HB-3, HB-4 and 3 new hybrids, namely, Tift.23D_2A × R.49

Table 1

Mean values of inbred parents and F_1 crosses regarding early growth vigour, forage and grain yield in bajra

S. No.	Inbred/crosses	Early growth[1] vigour (g)	Forage yield[2] (g)	Grain yield per plot (g)
1.	Tift. 23A	17.7	125.7	280.2
2.	Tift. $23D_2A$	18.3	150.9	191.5
3.	23—3	9.1	98.2	44.8
4.	49—2	13.6	118.6	142.3
5.	52—2	19.8	144.3	191.0
6.	19—7—8	41.3	238.3	243.0
7.	19—33—36	22.1	126.2	212.7
8.	97—4	17.8	91.9	93.9
9.	147—3	10.2	113.8	150.8
10.	177—2	15.0	77.6	161.8
11.	192—1	19.8	149.5	128.7
12.	199—1	24.7	196.0	206.1
13.	209—5	17.2	131.4	305.1
14.	K—560	14.7	127.6	165.4
15.	Tift. 23A × 23—3	21.3	164.1	447.3
16.	Tift. 23A × 49—2	33.5	177.4	434.0
17.	Tift. 23A × 52—2	36.7	190.3	469.7
18.	Tift. 23A × 19—7—8	31.7	163.2	412.2
19.	Tift. 23A × 19—33—36	20.8	203.7	328.3
20.	Tift. 23A × 97—4	26.8	198.2	420.2
21.	Tift. 23A × 147—3	30.2	291.6	335.0
22.	Tift. 23A × 177—2	19.9	147.1	482.2
23.	Tift. 23A × 192—1	32.0	190.7	555.1
24.	Tift. 23A × 199—3	26.6	186.9	389.2
25.	Tift. 23A × 209—5	35.0	256.8	411.6
26.	Tift. $23D_2A$ × 147—3	29.2	226.2	349.4
27.	Tift. $23D_2A$ × 97—4	33.1	146.1	577.5
28.	Tift. $23D_2A$ × 19—33—36	21.3	117.9	414.9
29.	Tift. $23D_2A$ × 177—8	28.8	162.7	304.7
30.	Tift. $23D_2A$ × R. 49	22.3	184.2	409.8
31.	Tift. $23D_2A$ × R. 91	28.4	175.5	467.6
32.	Tift. $23D_2A$ × R. 117	18.4	130.8	370.8
33.	HB-3	39.0	170.7	395.5
34.	HB-4	19.4	133.7	418.5
	C. D. 5%	13.0	141.4	238.6

[1] Dry weight of 5 thirty days old plants
[2] Dry weight of 5 random plants at heading stage

Table 2

Mean squares for different characters for inbred parents and F_1 crosses in bajra

Source	D. F.	Early growth vigour	Days to 50% heading	Forage yield	Grain yield
Parents	13	181.2*	196.5	5162.5*	1449.2*
Crosses	19	118.1*	220.3	5249.4*	14359.4*
Parents vs. crosses	1	12025.3**	346.0	52004.1**	1423169.3**
Error	66	64.53	216.5	2500.8	7124.6

* and ** = significant at 5% and 1% level respectively

Tift.23D_2A × R.91 and Tift.23D_2A × R.117, which are currently in co-ordinated trials, were also included in the study.

The material was evaluated in a randomized complete block design with 3 replications in the 1973 kharif (rainy season). Each plot consisted of five 4.5 m long rows spaced 45 cm apart. Only the middle 3 rows were used for recording the data. The dry weight of 5 randomly selected 30 days old plants from each plot was recorded as a measure of early growth vigour. Similarly, the dry weight of 5 randomly selected plants from each plot when it reached 50% heading was recorded as a measure of forage yield. The grains produced by all the remaining plants were taken as grain yield/plot. The number of days from planting to 50% heading was recorded as days to heading.

The standard statistical method (SNEDECOR—COCHRAN 1968, 299—310) was used for the analysis of variance and for the partitioning of the treatment variance into components due to parents, crosses, and parents versus crosses comparisons. Phenotypic and genotypic correlation coefficients were calculated by finding the appropriate phenotypic and genotypic covariance and variance components using the procedure given by AL-JIBOURI *et al.* (1958). The correlation coefficients between different characters were calculated for parents and crosses separately and also for combined data, but only the last is reported because the coefficient values for the two groups were similar. Partial correlation coefficients were calculated according to SNEDECOR—COCHRAN (1968, 400—402). The heritability for each character was calculated as the regression coefficient (b) of crosses on their mid-parent values (FALCONER 1960, 171—172). Data from only 15 hybrids (Table 1) whose parents were included in this study were used to find the "b" values.

The mean values of inbred parents and crosses regarding early growth vigour, forage yield and grain yield are given in Table 1. The overall mean values of parents for early growth vigour, forage yield and grain yield were 18.7 g, 135.0 g and 179.8 g respectively. The corresponding values for the 15 crosses, whose parents were included in this study, were 28.5, 188.2 and 422.1 g respectively representing 52.4, 39.4 and 134.5 per cent increase in early growth vigour, forage yield and grain yield, respectively, over the parental means. The mean number of days to heading was similar for the parents (63.3 ± 1.2) and the crosses (62.1 ± 0.8). Therefore, individual values are not given in the tabular form.

Variance components due to parents, crosses, and parents versus crosses comparisons were significant for all the characters except days to heading (Table 2). Parents versus crosses comparisons accounted for the major part of the treatment variance for these characters, indicating the manifestation of heterosis. Variation in the forage yield may also be caused by the duration of the growth period, that is, from the date of sowing to the date of 50%

Table 3

Phenotypic (P) and genotypic (G) correlation coefficients between early growth vigour, days to heading, forage yield and grain yield in bajra

Characters		Days to heading	Forage yield	Grain yield
Early growth vigour	P	0.30	0.71**	0.62**
	G	0.33	0.90**	0.76**
Days to heading	P		0.15	0.33
	G		0.27	0.39
Forage yield	P			0.43**
	G			0.52**

** = significant at 1% level

heading in the present case, in addition to variation in the inherent vigour of the genotypes. However, in the present material the duration of the growth period for forage yield was almost the same; therefore, it can be concluded that the variation observed in the forage yield represented variation in the inherent vigour of the genotypes. Such an inference, however, could not be derived for the grain yield because the duration of the filling period from heading to maturity was not studied.

Both the phenotypic and genotypic correlation coefficients of early growth vigour with forage as well as grain yield were positive and high (Table 3). The correlation coefficient between forage and grain yield was also significant. But when the effect of early growth vigour was kept constant, the partial correlation between the two approached zero ($r = 0.02$), indicating that the positive association between the two is only indirect, caused by their association with the early growth vigour. The partial correlation coefficient of early growth vigour with forage yield, keeping the grain yield as a constant, were similar to their respective correlation coefficient. The results, therefore, suggest that an improvement in early growth vigour should result in a concomitant improvement in the forage as well as the grain yield. Days to heading did not have a significant correlation with any of these characters.

Heritability values, which were based on the additive gene effects, were 0.26, −0.14 and −0.13 for early growth vigour, forage yield and grain yield, respectively. The negative heritability values for forage and grain yields might have arisen out of sampling variation around the true low values. The low heritability values of forage and grain yields indicate that the direct selection for these characters will not be effective. Similar conclusions were arrived at by BURTON (1959). For forage yield, however, direct selection would be effective, as its heritability is relatively high. Furthermore, this character showed a high positive correlation coefficient with forage and grain yield; therefore, this character could be used as a selection criterion for the improvement of these characters.

On the basis of the low value of narrow sense heritability and the high degree of heterosis for forage and grain yields, which have been observed in the present study, it may be suggested that while using early growth vigour as a selection criterion, the breeding procedures which capitalize on the non-additive gene action should be used to achieve rapid improvement in these characters. Since the two attributes, forage yield and grain yield, were not negatively correlated, the results suggest the possibility of producing a dual-purpose variety.

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VOLATILE OIL PRODUCTION AND FORMATION IN ACHILLEA MILLEFOLIUM SSP. COLLINA BECKER (A. COLLINA BECKER)

Achillea is often grown in Hungary and is used as a medicinal plant under the collective name: *Achillea millefolium* L. From this herb the essential oil "*Oleum millifoli*" is prepared, which is dark blue in colour and has a high azulene content.

Many authors have directed their work towards the systematic study of *Achillea* (Ehrendorfer 1953, Hess *et al.* 1972, etc.) and of polychemism in this plant (e.g. Kosová 1959, Kotilla 1959, Kučera 1956, Máthé *et al.* 1963, Michaluk—Oswiecimska 1959, Ruminska 1965, Stahl 1952 and Tétényi *et al.* 1964). Oswiecimska has carried out many cytological investigations on this genus: 1962, 1963, 1966a, 1966b, 1966c, 1968 and 1974.

The Hungarian authors and Oswiecimska state that the proazulene content in the *Achillea* plant is a special character under strong genetic control.

In this study we wished to investigate the oil formation during the ontogeny of this plant. We collected well identified plants from four places representing different locations in Hungary.

In this article we should like to give some preliminary information about this project based on results of one year's investigations.

Firstly we must deal with the problem of the identification of our plant material. It can be established that the plants collected from all four places is *Achillea millefolium* ssp. *collina* (+ *Achillea collina* Becker), according to Ehrendorfer (1953, 1959), Hess *et al.* (1972) and Soó—Kárpáti (1968). They all agree that it is difficult to distinguish between the two species. Our plant material has a mean value of 1.5 mm for the leaf width, so we

Table 1

The oil percentage at different stages of growth in different localities on the basis of fresh material

Growing stage	Daránypuszta			Ságváriliget		
	Date	Oil %	$X-\bar{x}$	Date	Oil %	$X-\bar{x}$
Vegetative stage	7. 5. 1974	0.017	−0.025	14. 5. 1974	0.020	−0.037
Budding stage	15. 7. 1974	0.060	+0.018	9. 7. 1974	0.070	+0.013
Flowering stage	15. 9. 1974	0.050	+0.008	9. 9. 1974	0.080	+0.023
Mean ($\bar{x}$)		0.042			0.057	

Kerepes			Farmos			Mean
Date	Oil %	$X-\bar{x}$	Date	Oil %	$X-\bar{x}$	$\bar{x}$
17. 5. 1974	0.020	−0.062	9. 5. 1974	0.037	−0.085	0.023
5. 7. 1974	0.140	+0.058	9. 7. 1974	0.180	+0.058	0,112
4. 10. 1974	0.085	+0.003	9. 9. 1974	0.150	+0.028	0.091
	0.082			0.122		

Statistical parameters

		Between localities	Between the growing stages
Standard deviation	S. D.	0.035	0.046
Standard error	S. $\bar{x}$	0.017	0.027
Coefficient of variation	C. v.	46%	61%

needed to calculate the chromosome number of this material. This was carried out after the method developed at the Cytogenetics Section of the Plant Breeding Institute, Cambridge, with the kind help of Mrs Rajki. We found that the chromosome number for our plant material from all the collections is n = 18 (2n = 36). Ehrendorfer, Oswiecimska and Hess referred to this race as *A. collina* Becker, although this does not agree with the morphological measurements. For this reason we decided to use the name *Achillea millefolium* ssp. *collina* Becker (*Achillea millefolium* Becker).

Here it may also be noted that LENKEY (1961) investigated some commercial *Achillea* drugs from Hungary in the pharmacognosy laboratory of Zofingen factory, Switzerland and he registered the name *Achillea millefolium* for this material, having blue, dark blue, and light blue oil.

Our plant material was collected from the following locations:

1 — Kerepes, 25 km northeast of Budapest;
2 — Ságváriliget, 10 km northwest of Budapest;
3 — Daránypuszta, 130 km southwest of Budapest;
4 — Farmos, 90 km southeast of Budapest.

Successive collections were obtained from these places representing the different stages of growth. The first sample was taken during May when the plant was at the vegetative stage. The second sample was obtained during July, i.e. representing the budding stage in which the plant has the first flowering buds. The third sample was collected during Septem-

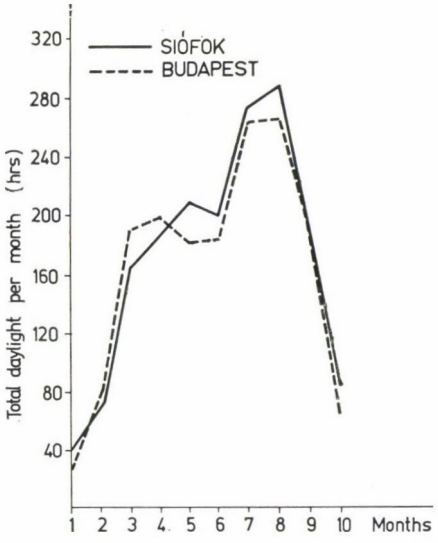

Fig. 1. Total daylight per month in Siófok and Budapest

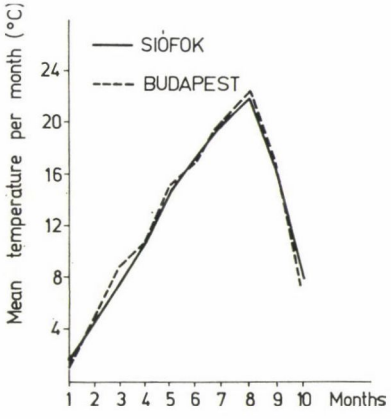

Fig. 2. Mean temperature per month in Siófok and Budapest

ber and October when the plants were in full flower. In all samples, the oil percentage was determined (HAGGAG *et al.* 1975) in the whole herb by steam distillation both in the fresh and air-dried material (about 25°C). In the sample representing the flowering stage, the oil percentage was also estimated in the different organs of the dry plant; leaves, stems and flowers.

Since environmental differences probably occur between the different localities, meteorological data for Budapest and Siófok were recorded (Figs 1 to 4). The data for Budapest may be applied to Kerepes and Ságvári liget, while the environment at Darány puszta is similar to that of Siófok. We were unable to obtain similar data for the Farmos region.

Table 1 and Fig. 5 illustrate the oil percentage at the different stages of growth in the different localities. The general trend is for the minimum oil content to occur in the

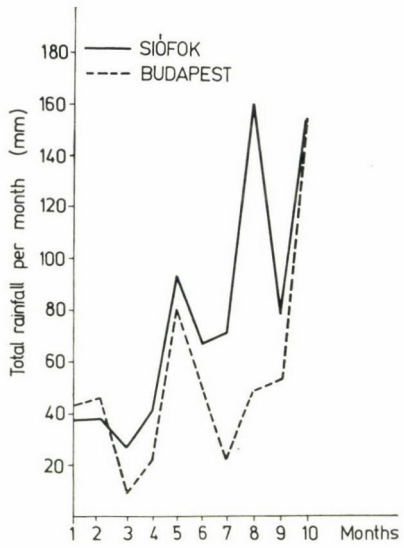

Fig. 3. Total rainfall per month in Siófok and Budapest

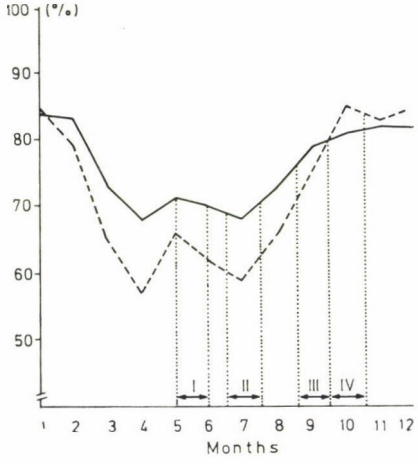

Fig. 4. Monthly mean of humidity (——— Siófok, – – – Budapest, I. Veget. s., II. Budd. s., III. Flower. s., IV. Sett. s.)

vegetative stage. With the beginning of flowering, when the plant was in bud, the oil percentage reached a maximum. Thereafter, it decreased during the autumn flowering period. This is in agreement with the results of WEBER—STAHL (1953), OSWIECIMSKA (1962), RUMINSKA (1970) and KUČERA (1956).

The data indicated that the maximum oil percentage was recorded in the flowers (0.20%) and the minimum in the stem (0.10%), based on the dry material. The leaves have an intermediate oil percentage (about 0.15%). RUMINSKA (1970), OSWIECIMSKA (1962) and BENZINGER (1957) found the same results. No oil could be detected in the roots and this also agrees with the results of TILLYAEV *et al.* (1973).

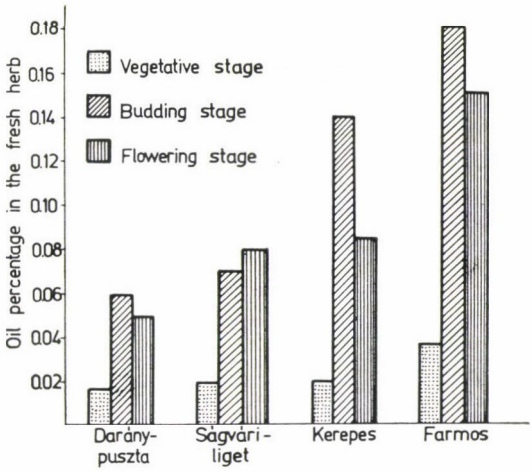

Fig. 5. The oil percentage in different stages from different localities

It seems that the fresh samples collected from Daránypuszta have a lower oil content than those which were collected from Kerepes and Ságváriliget. This is in accordance with the meteorological data, which illustrate that the Siófok region has a higher total rain fall and relative humidity than Budapest. On the other hand, the plants collected from the Farmos region have the highest oil content. Since we were unable to obtain meteorological data for this region, we can suggest that this may be due to environmental changes and/or to the soil effect (Farmos has sandy soil).

In all the stages the volatile oil had a dark blue colour, caused by the high azulene content.

The above results suggest that the successive formation of oil in the different stages of growth and different organs of the plant is under genetic control. There is a possibility that the oil content of the plant differs from one place to another according to the environmental conditions, but the general trend is always the same. MÁTHÉ *et al.* (1963) and OSWIECIMSKA (1966a, 1966b, 1966c), working on the *Achillea* plant, came to the same conclusion. In our plant material we find a characteristic onto-genetic rhythm in the formation of the oil content.

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PERICARP THICKNESS, IMBIBITION RATE AND DRYING RATE OF OPAQUE-2 MAIZE (ZEA MAYS L.) AND ITS NORMAL ANALOGUE

Opaque-2 maize varieties are reported to contain 1.8—4.2% more moisture in the grains at harvest than their normal analogues (LAMBERT *et al.* 1969, PAEZ *et al.* 1969). Higher moisture content requires additional drying after harvest. GUPTA—KOVÁCS (1973) reported that the opaque-2 maize pericarp was 36.3% thicker than that of normal maize and this led to reduced water loss at harvest. Therefore, a study was undertaken to determine the

Table 1

Mean pericarp thickness for excised pericarp strips from normal, opaque and H. E. opaque kernels

Kernel type	Percarp thickness in microns
Normal	97.0 ± 2.7
Opaque	78.8 ± 2.3
H. E. opaque	91.0 ± 1.8

morphological factors responsible for the higher moisture content in opaque-2 kernels at harvest.

Rattan, an opaque-2 composite, and its normal analogue, Vijay, available in the Indian Maize Programme were used in the study. Both the chalky and the hard endosperm (H.E.) kernels of the opaque-2 composite were included in the study.

The pericarp was carefully removed from the kernels after soaking them for 1—2 hours in water. The pericarp thickness was determined by the method outlined by WOLF *et al.* (1969) and modified by HELM—ZUBER (1969) using a micrometer. Each excised pericarp strip was measured at six locations, three on the abgerminal and three on the germinal surface. The thickness values reported herein are averages of fifteen pericarp strips.

The "rate of imbibition" as well as the "rate of drying" were determined. For imbibition studies 100 kernels of each class were soaked in water for various lengths of time at 25 ± 1°C and the "imbibition rate" was determined as an increase in weight per 100 g of initial weight per hour. The initial moisture content of whole kernels as well as kernels without a pericarp was about 8.5%.

In order to determine the "rate of drying" the kernels were dried at 40 ± 1.5°C. Kernels of three categories with and without pericarp, taken from the imbibition experiment were used for this study. The mean moisture content of whole kernels of normal, chalky opaque and H.E. opaque was 30.2, 36.0 and 31.1% respectively and that of kernels without a pericarp was 36.6, 49.3 and 45.2% respectively. For drying, 100 kernels from each category were put into an oven for different lengths of time and the loss in weight was determined. The "drying rate" was expressed as loss in moisture per 100 g initial dry weight per hour.

Table 1 shows that the average pericarp thickness of normal, chalky opaque and H.E. opaque kernels was 97.0 μ, 78.8 μ and 91.0 μ respectively. Thus the pericarps of chalky opaque and H.E. opaque kernels were respectively 18.6% and 6.2% thinner than that of their normal counterpart. It also suggested that modifier genes responsible for increasing the kernel vitreosity of opaque maize kernels are also responsible for or closely associated with loci which tend to increase the pericarp thickness; the pericarp of H.E. opaque kernels is about 15% thicker than that of chalky opaque kernels. The observation of a thinner pericarp in chalky opaque kernel types than in their normal analogue is in contrast to the observation of GUPTA—KOVÁCS (1973), who recorded 36.3% greater thickness in opaque-2 pericarps. Moreover, in general the mean pericarp thickness values were considerably higher than those recorded in the present study. Probably the pericarp thickness is dependent to a considerable extent on the genetic background as well as on the environmental conditions under which the crop is grown.

Over different intervals the imbibition rate and drying rate of whole kernels, as well as kernels without a pericarp, showed the following general trend: chalky opaque > H.E.

Table 2

Imbibition rate of normal, opaque and H. E. opaque kernels with and without pericarp

Kernel type	Imbibition rate (increase in wt./100 g initial wt./hour)				
	0—6 hrs	6—12 hrs	12—18 hrs	18—24 hrs	0—24 hrs
			Whole kernels		
Normal	3.11	1.11	0.35	0.08	1.17
Opaque	4.15	1.95	0.55	0.82	1.87
H. E. opaque	4.11	1.16	0.68	0.25	1.55
			Kernels without pericarp		
Normal	5.28	1.20	0.48	0.00	1.74
Opaque	8.78	1.67	0.90	0.00	2.85
H. E. opaque	6.98	2.18	0.75	0.40	2.62

Table 3

Drying rate of normal, opaque and H. E. opaque kernels with and without pericarp

Kernel type	Drying rate (loss in moisture/100 g initial dry wt./hour)			
	0—6 hrs	6—18 hrs	18—24 hrs	0—24 hrs
		Whole kernels		
Normal	1.95	1.24	.042	1.58
Opaque	2.57	1.53	0.30	2.39
H. E. opaque	2.22	1.37	0.38	1.91
		Kernels without pericarp		
Normal	4.70	2.25	0.45	1.96
Opaque	6.87	5.53	0.79	3.50
H. E. opaque	5.88	4.10	0.80	2.90

opaque > normal (Tables 2—3, Figs. 1—2). In kernels where the pericarp has been removed both the imbibition and drying rates were higher compared to their respective whole kernels. This suggested the effective role of the pericarp in controlling the inward and outward movement of water. The imbibition rate (0—24 hrs) of chalky opaque and H.E. opaque whole kernels was respectively about 60% and 32% higher than that of normal kernels, while the drying rate (0—24 hrs) was respectively about 51% and 21% higher.

From the study it appears that both the imbibition and drying rates are inversely proportional to the pericarp thickness. However, the pericarp thickness alone does not appear to be responsible for governing the moisture content in the grain harvest, particularly in opaque-2 materials. If the pericarp thickness were the only factor, the imbibition rate as well as the drying rate should have been more or less equal for all three kernel types tested after removing their pericarps, which was not observed to be the case in the present study. In fact the imbibition and drying rates were considerably higher for opaque kernel types

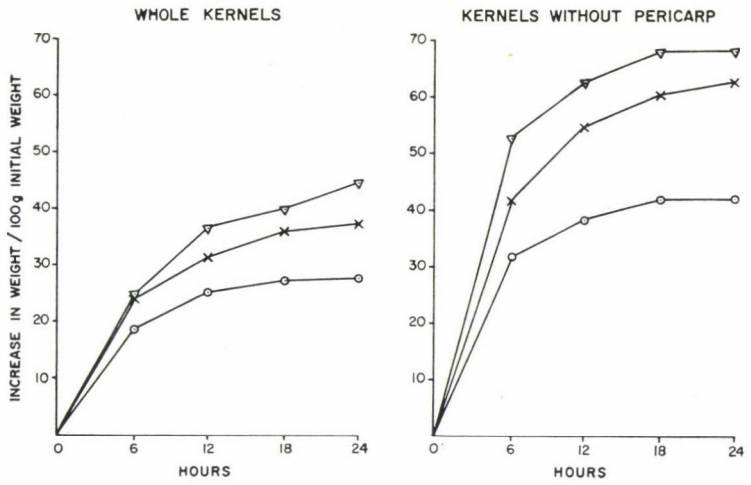

Fig. 1. Relative imbibition of normal, opaque and H.E. opaque kernels with and without pericarp at 25°C (○——○ Normal, ▽——▽ Opaque, ×——× H. E. opaque)

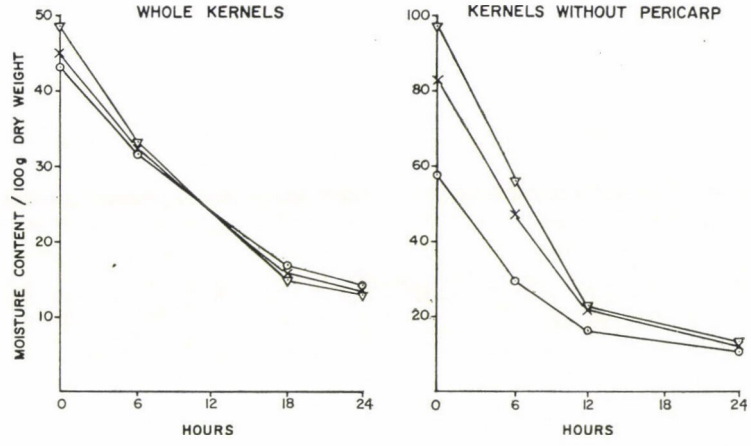

Fig. 2. Relative drying of normal, opaque and H.E. opaque kernels with and without pericarp at 40°C (○——○ Normal, ▽——▽ Opaque, ×——× H.E. opaque)

compared to normal ones. The fact that the initial drying rate of opaque kernels was observed to be equal to or even higher than the normal kernels, whereas a higher moisture content has been reported in opaque-2 grains at harvest (LAMBERT *et al.* 1969, PAEZ *et al.* 1969), requires special consideration. Obviously this could be explained in two ways. Firstly the total moisture content in opaque kernels may be higher at physiological maturity due to the fact that starch granules in the endosperm of opaque-2 kernels are loosely packed (DILMER 1966) and their interspaces might be filled up faster with additional water. Secondly the moisture retentive capacity depends to a considerable extent on the tension at which the moisture is held by the endosperm particles (starch, lipid or protein). This in turn would depend upon the size of the endosperm constituents and on the total surface area generated by them in the endo-

sperm. The opaque-2 gene is known to modify endosperm texture (CREECH 1968). However, additional information on various genotypic–environmental backgrounds is necessary for further analysis.

*

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EFFECT OF THE SPECTRAL COMPOSITION OF LIGHT ON DRY MATTER PRODUCTION IN SOLANUM DULCAMARA L. ECOTYPES OF DIFFERENT ORIGIN

Solanum dulcamara L. can be found on almost the whole of the holoarctic floristic area. It is only recently, due to the increasing demands for steroid raw material made by the pharmaceutical industry, that detailed work has begun on the assessment of its distribution and the analysis of its steroid glycoalkaloid content. The species occurs under highly diversified ecological conditions: it may be equally characteristic of marsh and heath plant communities (SOÓ 1968). Its high adaptability is also shown by the morphological differentiation within the species. In SOÓ's (1968) system 17 taxons (varietas, forma, lusus) can be found within the species, and continued research work is further increasing this number (MÁTHÉ JR. 1974).

The chemotaxonomic systematization of the species seems to be more uniform. Taking into consideration their own investigations together with foreign results, MÁTHÉ—MÁTHÉ JR. (1973) identified four infraspecific chemical taxons on the basis of the steroidaglycons which occur in the largest quantities. However, the occurrence of these chemotaxons, like that of the morphological taxons, is regionally determined, so for these properties a parallelism between adaptation and chemical differentiation can again be assumed.

In spite of the fact that the natural occurrence of morphological and chemical taxons of this species has been analysed in great detail, exact experiments to discover its relation with the environment are hardly known.

Our earlier investigations showed that, of the environmental factors, the spectral energy distribution of the light greatly influences the steroidaglycons, which are of importance from a practical point of view. The aim of our current experiments was thus to find out what effect this environmental factor exerts on the dry matter production of plants of different chemism and ecological requirements.

In order to determine the similarities and differences dependent upon site of origin and on morphological and chemical differentiation investigations were carried out on the

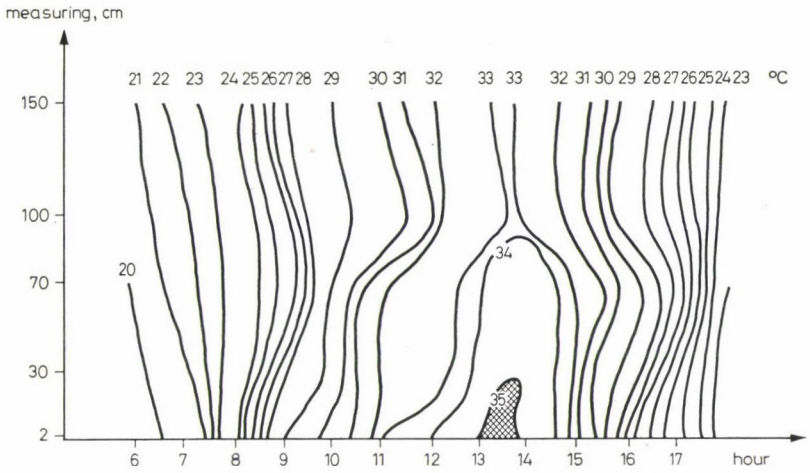

Fig. 1. Daily changes in air temperature at the exposed site on Palotai island (29. 8. 1974)

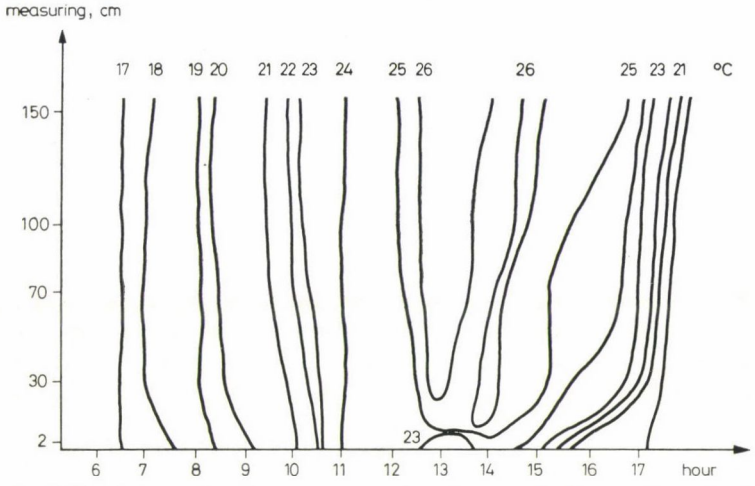

Fig. 2. Daily changes in air temperature at the closed site on Palotai island

following four ecotypes of *S. dulcamara: a)* var. *dulcamara* f. *variifolium* containing solasodin as the main aglycon (A_1), *b)* var. *dulcamara* f. *variifolium* containing soladulcidin as the main aglycon (A_2) — both originating from sunny growing sites; *c)* var. *dulcamara* f. *cordifolium* with mixed aglycons (B_1) and *d)* var. *dulcamara* f. *variifolium* with soladulcidin as the main aglycon (B_2) — both obtained from shady growing sites.

The plants were chosen on the basis of examinations carried out in 1974. On the basis of chemotaxonomic surveys (Vo Hong Nga *et al.* 1976) we succeeded in finding a well-defined population within the Budapest area on the approx. 2.7 km long Palotai island. Growing sites showing considerable ecological differences can be found on the island: the exposed embankment and the inner, multi-level closed stand are very diverse.

At these two sites microclimate studies were also carried out, the results of which, obtained on a clear day, are shown in Table 1 and Figs 1 and 2. The daily course of the air temperature was measured at heights of 2, 30, 70, 100 and 150 cm, the relative humidity of the air at 70 cm, and the daily changes of light intensity at a height of 5 cm above the ground.

Table 1

Daily course of light intensity and relative humidity at the original site of plants (A_2, B_2) used in our experiments (29. 8. 1974., Palotai island)

Time	Light intensity (lux)		Relative humidity (%)	
	sunny	shady	sunny	shady
	site		site	
06.30	4,500	225	85	88
07.00	8,000	440	83	86
07.30	13,200	600	70	85
08.00	16,000	900	62	81
08.30	25,000	1,180	53	71
09.00	28,000	920	46	59
09.30	50,000	1,080	46	59
10.00	52,000	4,600	45	60
10.30	58,000	6,500	40	60
11.00	62,000	2,200	38	55
11.30	66,000	2,100	38	50
12.00	70,000	6,200	38	41
12.30	68,000	3,600	34	40
13.00	62,000	1,480	34	42
13.30	56,000	1,860	34	41
14.00	55,000	1,300	35	50
14.30	42,000	4,000	35	36
15.00	38,000	1,900	31	38
15.30	11,800	700	32	36
16.00	22,000	900	32	40
16.30	14,000	500	33	39
17.00	4,800	350	37	48
17.30	3,900	220	38	65

These significant microclimatic differences also resulted in a uniform morpho-phenological differentiation in the *S. dulcamara* population. The chemism of the population, on the other hand, appeared to be uniform at the two sites and did not show any dependence upon the character of the site. Plants obtained from the two sites thus seemed suitable for evaluating effects independent of chemism (A_2-B_2).

The morphological characterization of these two types of plant is given on the basis of surveys made at the original growing sites every two weeks throughout the whole vegetation period in 1974. We measured plant height, anthocyan level, length of internode and leaf area, and studied the tissue structure of the leaf.

Since it was highly uniform for chemism (containing soladulcidin as the main aglycon) the population was not suitable for demonstrating differences depending upon chemical differentiation. Test plants for this purpose were therefore chosen from the variety collection of the Research Institute for Medicinal Plants (A_1-B_1). Their original growing site was

Table 2

Percentage spectral energy distribution of light treatments of different wave-lengths (nm)

Treatment	400–436	436–495	495–566	566–589	589–627	627–700
"blue"	25.6	59.1	15.3	—	—	—
"red"	—	—	—	1.0	20.2	78.8
"violet"	19.8	24.2	3.6	2.6	9.2	40.6

Table 3

Characterization of the experimental plant material

Designation	Taxonomic category		Original site	Habit	Antho-cyan	Inter-node cm	Average leaf	
	form	chemotaxon					area cm^2	thick-ness, μ
A_1*	variifolium	solasodin	exposed	erect	+++	2.4	5.2	25.1
A_2**	variifolium	soladulcidin	exposed	erect	+++	2.3	7.8	17.0
B_1*	cordifolium	mixed	shady	procumbent	—	3.6	14.5	21.2
B_2**	variifolium	soladulcidin	shady	climbing	—	5.3	20.9	10.6

* Measurements carried out under identical conditions.
** On the basis of continuous surveying at the original site.

deduced from the morphophenological differentiation shown in the population trial.

In accordance with our objectives the use of plants thus selected made it possible to study differences in the site-dependent responses of identical morpho- and chemotaxons (A_2—B_2), of plants with identical morphology but different chemism (A_1—B_2) and of those different in both morphology and chemism (A_1—B_1).

The plants were uniformly propagated by raising clones from green shoot tops with 2—3 leaves. (Clones were raised from cuttings in order to exclude the genetic uncertainty resulting from cross pollination in the case of propagating by seed.) The cuttings were raised in sand culture and treated with Knopp culture fluid. The experiment included 3 replications per treatment and clone, with 4 plants per replication. A constant water content was maintained by supplying distilled water every day. Once a week uniform amounts of culture fluid were applied.

The experiments were carried out in 1975 in the phytotron of the Botanical Garden of the József Attila University. The light treatment applied was of three different spectral energy distributions (Table 2). The light energy was the same in all three treatments: $1.8 \cdot 10^{-2}$ cal $cm^{-2}min^{-1}$.

According to the results of examinations on the populations, the experimental material showed a statistically proved (Vo Hong Nga 1975) differentiation depending on the site of origin, as seen in Table 3 and Figs 3 and 4.

It can be established that in places exposed to sunshine the anthocyan level of the plants is higher, the habit changes, the shoots and internodes become shorter, the leaf area decreases, the thickness of the leaves and the number of palisade cells increase. The relative stability of these differences is shown by the fact that they could also be found, though to

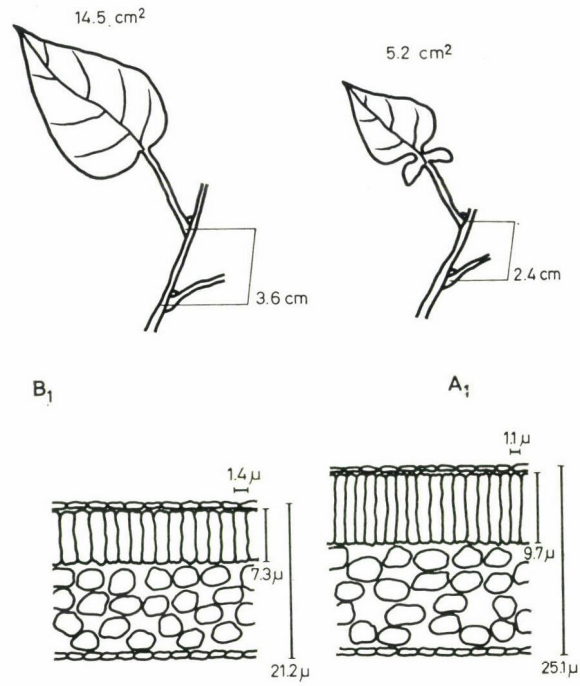

Fig. 3. Differentiation in the experimental material as a function of the site of origin

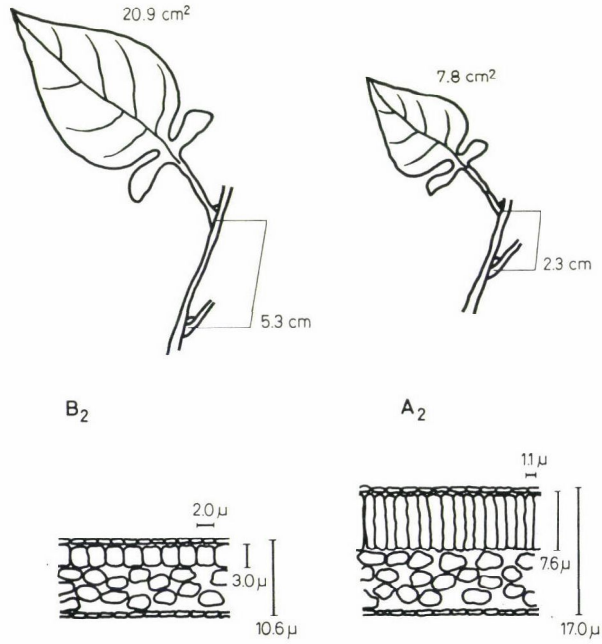

Fig. 4. Differentiation in the experimental material as a function of the site of origin

Table 4

Changes in morphological characters as a function of the spectral composition of light

Designation	Plant height (cm)			Average leaf area per plant (cm^2)			Ratio of spongoid to palisade parenchyma
	"B"	"R"	"V"	"B"	"R"	"V"	
A_1 (sunny)	11.8	16.4	18.6	104.9	72.0	148.7	1.5
A_2 (sunny)	16.4	23.3	17.9	147.4	94.5	157.0	1.2
Mean	14.6	19.8	18.2	126.1	83.2	152.8	1.3
B_1 (shady)	14.1	27.5	23.2	127.6	160.3	193.9	1.9
B_2 (shady)	17.6	41.2	37.5	150.6	129.8	193.9	2.5
Mean	15.8	34.3	30.3	139.1	145.0	193.9	2.2

"B" = blue light
"R" = red light
"V" = violet light

a lower extent, in plant material raised at the institute under the same conditions (A_1—B_1). The identical conditions of the experimental area caused the greatest decrease in the differences between leaf thickness and tissue structure, although these differences were still conspicuous.

According to our investigations, parallel to the morphological changes occurring during the adaptation, the metabolic processes are modified too. This result agrees with the observations of GAUHL (1972), who found, when studying the light-dependent reactions of plants originating from different sites, that the photosynthetic regulation of plants obtained from shady places was reduced. This is confirmed by the results demonstrated in our investigations concerning the extent of dry matter production and changes in morphological characters (Tables 4 and 5).

The height and leaf area of plants show similarities depending on the species, and differences determined by the site of origin (Fig. 5). At the relatively low energy level applied in our experiments (due to colour filters) plants originating from shady growing sites displayed more favourable growth and had a larger leaf area too, irrespective of the morphological and chemical taxons they belonged to. The most favourable growth characteristics for the species were obtained as a response to "red" and "violet" light treatments, respectively, in all ecotypes and chemical taxons, while the leaf area was unambiguously determined by the site of origin. In the case of plants originating from sunny places the leaf area was larger in light showing a richer spectral composition in the short (blue) wavelengths, while plants obtained from a closed stand produced a larger leaf area in light richer in the longer (red) wavelengths.

The dry matter production showed trends similar to the changes in leaf area (Fig. 6). It can be unequivocally established that its extent is determined by the character of the original growing site, irrespective of the morphological and chemical taxon. This is proved by the fact that while the dry matter production of plants originating from the same site shows no significant difference under the influence of different light treatments (the value of χ^2 is 3.2 at the shady growing site (B_1—B_2) and 2.9 at the sunny site (A_1—A_2); the value in the table given at the 10% level is 4.6), the dependence of production upon the original site shows significant differences at the 0.1% level. The higher dry matter production of plants

Table 5

Changes in the dry matter production of plants as a function of the spectral composition of light

Designation	Dry weight per plant (mg)											
	root			shoot			leaf			total		
	"B"	"R"	"V"	"B"	"R"	"V"	"B"	"R"	"V"	"B"	"R"	"V"
A_1 (sunny)	28.9	22.0	27.0	56.1	57.8	52.7	93.4	71.8	109.3	178.4	151.6	189.0
A_2 (sunny)	66.3	41.3	71.6	72.0	66.6	88.6	81.0	45.6	83.0	219.3	153.5	243.2
Mean	47.6	31.6	49.3	64.0	62.2	70.7	87.2	58.7	96.1	198.8	152.5	216.1
B_1 (shady)	70.0	101.0	105.9	101.1	141.5	160.5	108.1	143.5	164.7	279.2	386.0	431.1
B_2 (shady)	50.0	52.6	60.0	62.5	94.0	114.3	87.5	80.3	125.0	200.0	226.9	299.3
Mean	60.0	76.8	82.9	81.8	117.7	137.4	97.8	111.9	144.9	239.6	306.4	365.2

"B" = blue light
"R" = red light
"V" = violet light

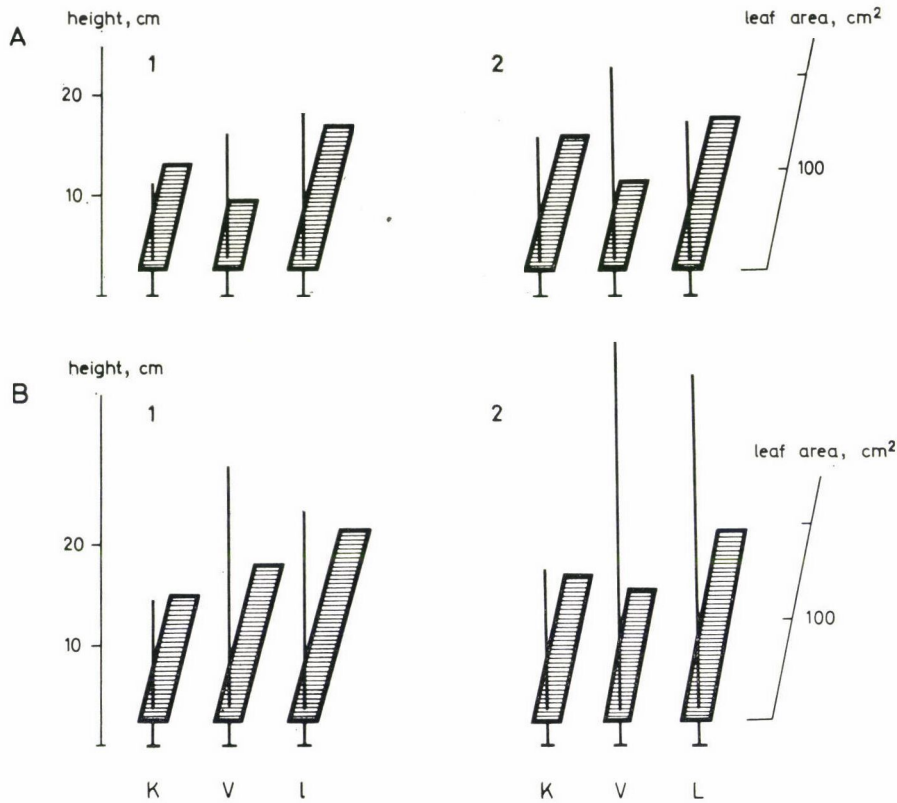

Fig. 5. Trends of plant height and leaf area

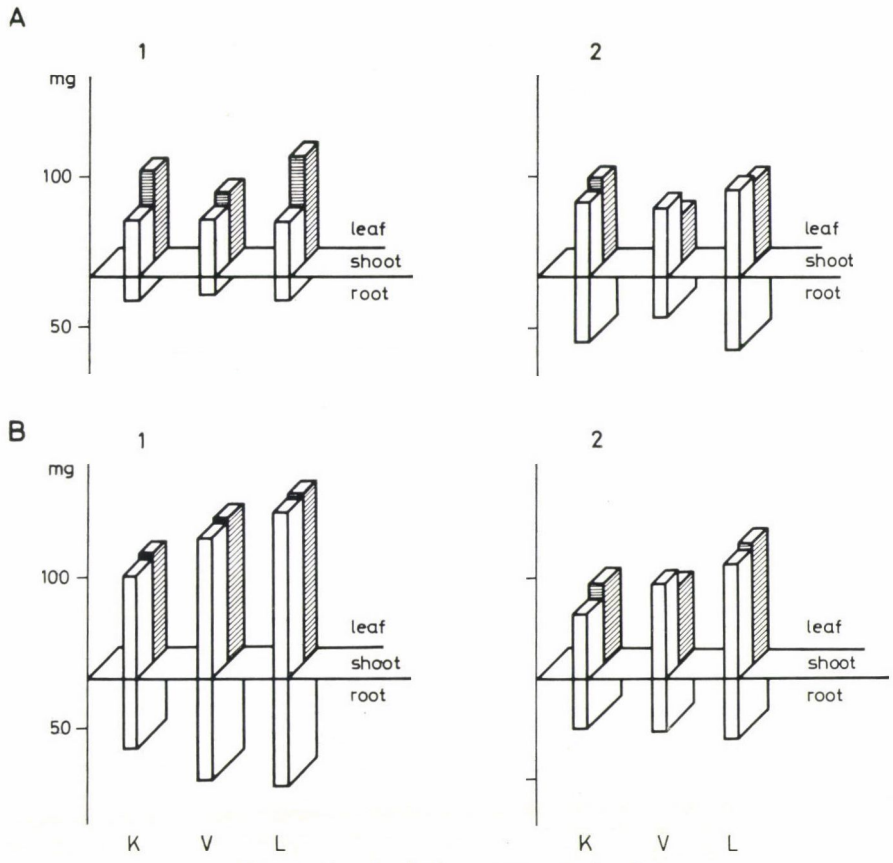

Fig. 6. Trend of dry matter production

obtained from a shady site is due to the fact that they utilize lights of different spectral composition to varying extents. The average χ^2 value of A_{1-2} and B_{1-2} is 220.3, this is significant at the 0.1% level (13.8 in the table); the increase in dry matter production in plants originating from the shady site is significant at the 5% level ($SD_{5\%} = 83.9$).

The greatest difference depending on the site of origin is caused by light rich in red rays. Under its influence the production in plants originating from the site exposed to sunshine considerably decreases, while in plants obtained from the shady site production increases compared to the effect of light treatment richer in short-wave (blue) radiation.

On the basis of these results it can be established that, besides geographical factors, site conditions also play a decisive role in the distribution of morpho- and chemotaxons of *S. dulcamara* and may result in the development of ecotypes independent of the morphological and chemical taxons. The habit of the ecotypes (length of shoot and internode, anthocyan level, leaf area, tissue structure of leaf, etc.) is independent of the morpho- and chemotaxons. Parallel to these morphological differences changes of an adaptational nature occur in the metabolic processes.

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ANALYSIS OF F_3 GENERATION OF BRASSICA CAMPESTRIS L.

A study of the inheritance of quantitative characters in oil-seeded *Brassica* is of considerable interest with respect to the breeding for commercial varieties, as most of the economic characters of the crop are quantitative in nature. Previous work was mostly concerned with the studies of qualitative characters, except for a few cases where quantitative characters were studied using F_2 and backcross data. In some of the studies the presence of a correlation between different quantitative characters has been reported in *Brassica* sp. (RAMANUJAN—RAI 1963, JOARDER—EUNUS 1969, ZUBERI—JOARDER—EUNUS 1972). The correlation may result from the interaction of genetic and non-genetic factors and genetic correlation may be due to pleiotrophic gene effects and linkage. With a view to clarifying this point, the present investigation was undertaken to study the inheritance of some quantitative characters including yield per plant in *Brassica campestris* L., using the F_3 generation, by estimating components of variation and covariation.

The following three varieties of *Brassica campestris* L. were chosen for the present study as they show well-marked differences in various quantitative characters.

a) Toria-A: Seed red, early heading and long heading to ripening period with short plant height.

b) Toria-BP: Seed white, late heading and short heading to ripening period with tall plant height.

c) Toria-TP: Same as Toria-BP but fruit having four chambers

Two crosses were made between the three varieties using Toria-BP and Toria-TP as the female parent (Toria-BP $\times$ Toria-A and Toria-TP $\times$ Toria-A). The F_1 plants were grown and F_2 seeds were obtained along with fresh F_1 seeds. The seeds of the F_2 generation and those of the F_1 and the parents were sown in three replications during the winter of 1968—69. One replication was put in a 450 $\times$ 600 cm block. The paths between the blocks were 90 cm wide, as was the border all round the field. Each block consisted of 16 rows with 21 plants in each row for each cross, the space between rows and that between plants in a row was 30 cm.

The border rows on two sides of a block were sown with parental seeds and were treated as non-experimental, while of the remaining 14 rows, the seeds of P_1, P_2 and F_1 were

Table 1

F_2 and F_3 statistics with their composition and observed values

Statistics	Composition	Heading date	Heading to ripening	Plant height at heading	Plant height at ripening	Yield/plant
Toria-BP × *Toria-A*						
V_{F_2}	1/2 D + 1/4 H + E_1	43.38	56.03	87.80	74.06	74.59
$V\overline{F}_2$	1/2 D + 1/26 H + E_2	38.64	32.29	54.46	54.86	49.78
$W_{F_2/\overline{F}_3}$	1/2 D + 1/8 H	35.44	45.30	34.66	34.67	41.78
$\overline{V}_{F_3}$	1/4 D + 1/8 H + E_3	44.89	56.47	49.86	59.21	46.47
E_1		8.89	12.16	19.59	11.47	12.80
E_2		0.88	0.98	1.98	1.12	1.36
E_3		9.33	8.80	15.80	17.69	12.28
Toria-TP × *Toria-A*						
V_{F_2}		41.44	47.08	47.50	54.34	83.11
$V\overline{F}_2$		36.25	25.69	40.90	53.16	54.12
$W_{F_2/\overline{F}_3}$		27.08	35.25	62.65	63.67	46.31
$\overline{V}_{F_3}$		25.80	46.54	76.23	84.47	47.30
E_1		7.68	9.63	12.99	17.21	17.80
E_2		0.86	1.00	1.30	1.72	1.85
E_3		10.72	10.27	13.44	16.40	18.65

sown in two rows each and the F_2 in 8 rows, the assignment of the rows being random. The end plant of each of these rows was treated as non-experimental. Thus there were 38 experimental plants for each of the P_1, P_2 and F_1 progenies and 152 plants for the F_2 generation in each block for each cross. Fresh crosses were made and F_1 and F_3 seeds were collected.

The two parents, the F_1 and 150 F_3 lines selected at random from the F_2 population of the previous year for each of the two crosses were grown in three replications during the winter of 1969—70. Five rows for each of the parental and the F_1 progenies, and one row for each of the 150 F_3 lines were randomly assigned in each replication. The field plan was similar to that of the previous year's experiment. Thus in each replication 95 experimental plants for each of the P_1, P_2 and F_1 progenies and 19 plants for each of the 150 F_3 families are available for experimental purposes.

The data, namely, heading date, heading to ripening period, plant height at heading and at ripening time, and seed yield per plant were collected on an individual plant basis and were analysed following the biometrical techniques of MATHER (1949), MATHER—VINES (1952) and NEI—SYAKUDA (1956).

A) *Component of Variation.* The method used in the analysis of variation is the same as that described by MATHER (1949). The statistics and their composition and observed values are shown in Table 1. The unweighted least square estimates of components of variation and analysis of variance are presented in Tables 2 and 3, respectively. The analysis has been conducted by the inclusive-exclusive method outlined by MATHER—VINES (1952) and MATHER—JINKS (1971). In the exclusive analysis D and H are estimated from $V\overline{F}_2$, $V\overline{F}_3$ and $W_{F_2/\overline{F}_3}$.

The estimate of D was significant in all the characters for the cross Toria-TP×Toria-A, whereas for Toria-BP×Toria-A it was only significant for heading date and the sowing to heading period. H was non-significant except for the heading date in Toria-BP×Toria-A, which was negatively significant. E_3 was significant in most cases, but E_1 in very few cases. The homogeneity between plants within a population was indicated by the non-significant E_2 estimate.

The number of effective factors was calculated in two different ways and two kinds of information as to the number of effective factors were obtained. When the number of effective factors was estimated by dividing the square of half the parental difference by D it was designated as K_1. On the other hand, it was termed as K_2 when it was determined by using the formula, $HV_{F_3}(V_{V_{F_3}} - C)$, where HV_{F_3} is the heritable mean variance of F_3 families and C is the correction factor for $V_{V_{F_3}}$ (obtained by dividing $2\overline{V}_{F_3^2}$ with the harmonic mean number of plants per F_3 families). The values obtained for K_1 and K_2 are shown in Table 2. The estimated K_1 indicated the presence of one effective factor, whereas the K_2 estimate suggested the presence of 1 to 12 effective factors conditioning the different characters investigated.

Heritability was high in most of the characters for the cross Toria-TP×Toria-A, whereas Toria-BP×Toria-A showed high heritability for the characters heading date and heading to ripening period (Table 2).

The test of linkage is the test of homogeneity of D and H over F_2 and F_3 taking into consideration the perfect fit of D and H for V_{F_2} and V_{F_3}. The comparison of the mean square of linkage with the pooled residual mean square (Table 3) indicated that there is a significant linkage for the characters heading date and plant height at ripening time in the crosses Toria-BP×Toria-A and Toria-TP×Toria-A. The heading to ripening period showed significant linkage in both the crosses.

B) *Component of Covariation.* The method used in the analysis of covariation is based on the principle set up by MATHER (1949) for the study of linkage between genes governing a single quantitative character. NEI—SYAKUDA (1956) have proposed a similar method for the estimation of linkage between genes governing different characters. Following NEI—SYAKUDA's (1956) notation the covariances of the generations concerned in the present investigation are:

$$W_{F_2} = 1/2\ L_1 + 1/4\ M_1 + U_1$$

$$W_{\overline{F}_3} = 1/2\ L_1 + 1/16\ M_1 + U_2$$

$$W_{F_3} = 1/4\ L_2 + 1/8\ M_2 + U_3$$

$$W_{F_2/\overline{F}_3} = 1/2\ L_1 + 1/8\ M_1$$

where U_1, U_2 and U_3 are environmental components, corresponding to E_1, E_2 and E_3. The test of linkage is a test of the homogeneity of L and M over ranks.

The analysis was conducted by the inclusive-exclusive method, as described for the components of variation. All possible combinations of the five characters were analysed. Tests of linkage were carried out and in no case was the linkage significant. The unweighted least square estimates for components of covariation are shown in Table 4. L was found to be significant in most cases, whereas M was significant in only a few cases, indicating the importance of the non-allelic gene interaction component to non-fixable genetic interaction in these quantitative characters of *Brassica* sp.

C) *Correlation studies.* The phenotypic (r_{ph}) and genotypic (r_g) correlations, as well as the correlation between additive genes (r_D) for the five characters are shown in Table 5. For the most part the correlation for any pair of characters appears to be comparable in

Table 2

Estimates of components of variation

	Heading date		Heading to ripening		Plant height at heading		Plant height at ripening		Yield per plant	
	Inclusive	Exclusive	Inclusive	Exclusive	Inclusive	Exclusive	Inclusive	Exclusive	Inclusive	Exclusive
Toria-BP × *Toria-A*										
D	68.07	77.04	67.23	81.74	57.86	59.58	55.76	62.45	53.21	56.37
	±27.10	±2.00	±47.79	±27.71	±35.81	±51.47	±42.83	±55.05	±34.31	±47.88
H	24.39	−21.26	46.24	−27.67	132.41	123.67	128.29	94.27	123.44	107.36
	±82.99	±6.40	±136.27	±88.69	±109.68	±164.72	±131.49	±176.18	±105.09	±153.22
E_1	5.56	9.03	4.58	10.19	22.57	23.24	12.79	15.37	14.96	16.18
	±7.98	±0.60	±14.07	±8.31	±10.54	±15.44	±12.64	±16.50	±10.10	±14.30
E_2	1.97	1.16	−1.61	−2.93	9.41	9.25	9.50	8.89	8.41	8.13
	±7.60	±0.54	±13.40	±7.59	±10.04	±14.09	±12.04	±15.07	±9.62	±13.11
E_3	17.07		21.33		17.36		23.46		15.00	
	±6.59		±11.63		±8.71		±10.45		±8.35	
K_1	0.09	0.08	0.13	0.11	0.28	0.27	0.01	0.01	0.11	0.11
K_2	5.17	4.27	1.96	1.47	1.93	1.88	12.13	11.08	2.46	2.35
$\sqrt{K_2 D}$	18.78	18.13	11.47	10.96	10.56	10.58	26.00	26.30	11.44	11.50
Heritability	80.95	90.47	60.71	73.21	33.02	34.48	36.48	40.78	35.31	39.18
Toria-TP × *Toria-A*										
D	60.69	60.42	51.58	62.28	78.50	77.80	91.69	108.64	77.15	74.81
	±11.96	±17.34	±35.40	±21.04	±54.23	±24.99	±52.81	±19.14	±19.72	±26.74
H	3.00	4.38	51.63	−2.86	136.24	107.49	126.98	40.70	104.67	116.57
	±36.65	±55.49	±108.43	±67.35	±116.10	±79.98	±161.75	±61.26	±60.39	±85.57
E_1	9.01	8.90	4.00	8.14	10.99	10.99	9.30	15.85	20.60	19.70
	±3.52	±5.20	±10.30	±6.31	±15.97	±7.49	±15.55	±5.74	±5.80	±8.02
E_2	3.28	3.31	−1.01	−1.98	−2.93	−2.26	0.54	−0.99	5.42	5.64
	±3.35	±4.74	±9.93	±5.76	±15.21	±6.81	±14.81	±5.24	±5.53	±7.32
E_3	10.48		19.94		26.18		31.03		16.62	
	±2.91		±8.61		±13.20		±12.85		±4.80	
K_1	0.41	0.43	0.34	0.19	0.16	0.16	0.06	0.05	0.15	0.16
K_2	0.40	0.41	3.06	2.38	12.21	10.96	7.86	6.47	7.02	7.21
$\sqrt{K_2 D}$	4.92	4.97	12.56	12.17	30.95	29.20	26.82	26.251	23.27	23.22
Heritability	71.17	71.02	53.19	65.95	52.70	51.35	85.18	98.12	43.31	42.04

Table 3

Analysis of variance

Item	d. f.	Heading date		Heading to ripening		Plant height at heading		Plant height at ripening		Yield per plant	
		m. s.	v. r.	m. s.	v. r.	m. s.	v. r.	m. s.	v. r.	m. s.	v. r.
Toria-BP × *Toria-A*											
Linkage (L)	1	432.58	113.58**	713.40	14.13*	14.72		230.01		27.23	
Residual (R)	1	3.29		135.27	2.68	757.63	2.94	687.58	2.98	182.31	2.16
Heterogeneity											
of L	2	10.17	2.66	0.53		0.61		13.32		2.06	
of R	2	5.72		8.07		7.37		1.55		35.38	
Pooled residual variation	3	3.81		50.40		357.45		330.22		84.34	
Toria-TP × *Toria-A*											
Linkage (L)	1	1.38		335.76	11.77*	1104.15	7.55	1569.26	28.05*	134.91	1.87
Residual (R)	1	94.23	2.33	56.40	1.97	366.97	2.50	109.38	1.98	203.83	2.83
Heterogeneity											
of L	2	14.68		0.31		35.88		2.99		18.84	
of R	2	13.45		14.85		35.83		29.22		6.02	
Pooled residual variation	3	40.38		28.60		146.21		55.95		71.94	

* Significant at 5% level
** Significant at 1% level

Table 4

Estimated values of components of covariation

	Toria-BP × Toria-A		Toria-TP × Toria-A	
	Inclusive	Exclusive	Inclusive	Exclusive
Heading date Vs Heading to ripening				
L	−30.77 ± 24.44	−38.54 ± 10.01	−25.13 ± 18.91	−31.15 ± 7.66
M	−40.76 ± 74.85	−1.20 ± 32.03	−70.23 ± 57.92	−39.59 ± 24.53
U_1	−1.91 ± 7.19	−4.91 ± 3.00	−2.55 ± 5.57	−4.88 ± 2.29
U_2	−2.44 ± 6.85	−1.73 ± 3.74	−1.71 ± 5.30	−1.16 ± 2.09
U_3	−12.90 ± 5.95		−12.33 ± 4.60	
Heading date Vs Plant height at heading				
L	24.57 ± 44.66	37.69 ± 30.04	75.93 ± 28.80	75.44 ± 3.48
M	147.43 ± 136.78	80.65 ± 96.13	21.92 ± 80.20	−26.49 ± 11.14
U_1	−0.04 ± 13.15	5.01 ± 9.01	0.71 ± 8.48	4.38 ± 1.04
U_2	−3.02 ± 12.52	−4.21 ± 8.22	1.41 ± 8.07	0.55 ± 0.95
U_3	17.35 ± 10.87		11.40 ± 7.01	
Heading date Vs Plant height at ripening				
L	−22.18 ± 32.50	−24.57 ± 46.11	−64.96 ± 19.16	−71.15 ± 6.14
M	−147.32 ± 99.71	−135.15 ± 147.57	−87.75 ± 58.70	−56.21 ± 19.67
U_1	−15.03 ± 9.58	−15.96 ± 13.83	−1.84 ± 5.64	−4.23 ± 1.84
U_2	−6.85 ± 9.13	−6.64 ± 13.00	−1.50 ± 5.37	−0.93 ± 1.68
U_3	−9.37 ± 7.92		−9.54 ± 4.66	
Heading date Vs Yield/plant				
L	30.68 ± 61.80	44.62 ± 65.79	77.47 ± 11.37	70.87 ± 7.14
M	207.22 ± 189.28	136.29 ± 210.53	−0.39 ± 34.85	−17.70 ± 22.87
U_1	9.93 ± 18.20	15.32 ± 19.73	6.39 ± 3.35	7.70 ± 2.14
U_2	11.27 ± 17.33	10.00 ± 18.01	−0.37 ± 3.19	−0.68 ± 1.95
U_3	24.33 ± 16.00		7.85 ± 2.76	
Heading to ripening Vs Plant height at heading				
L	−32.06 ± 33.74	−28.11 ± 45.85	−46.36 ± 40.74	−58.06 ± 29.41
M	−112.44 ± 103.33	−132.55 ± 146.72	−116.55 ± 124.77	−56.92 ± 94.27
U_1	−11.08 ± 9.93	−9.56 ± 13.75	−4.59 ± 11.99	−9.11 ± 8.83
U_2	−6.21 ± 9.46	−6.57 ± 12.55	2.16 ± 11.42	3.22 ± 8.06
U_3	−1.03 ± 8.21		−18.93 ± 9.91	

(Continued overleaf)

Table 4 (continued)

	Toria-BP × Toria-A		Toria-TP × Toria-A	
	Inclusive	Exclusive	Inclusive	Exclusive
Heading to ripening Vs Plant height at ripening				
L	42.16 ± 52.67	57.89 ± 33.21	32.94 ± 41.22	87.49 ± 37.99
M	116.04 ± 161.33	35.98 ± 106.27	155.00 ± 126.26	83.71 ± 121.59
U_1	−1.45 ± 15.51	4.61 ± 9.96	−3.42 ± 12.14	13.23 ± 11.39
U_2	6.15 ± 14.77	4.72 ± 9.00	−2.69 ± 11.56	−3.93 ± 10.40
U_3	21.77 ± 12.82		18.08 ± 10.03	
Heading to ripening Vs Yield/plant				
L	56.34 ± 53.96	68.33 ± 35.02	54.53 ± 8.04	51.88 ± 1.37
M	148.09 ± 165.27	66.65 ± 112.06	67.76 ± 24.64	81.24 ± 4.40
U_1	−2.23 ± 15.37	3.94 ± 10.50	6.16 ± 2.23	5.14 ± 0.41
U_2	−3.28 ± 15.13	−4.74 ± 9.59	−0.14 ± 2.25	0.09 ± 0.37
U_3	22.81 ± 13.11		2.37 ± 1.95	
Plant height at heading Vs Plant height at ripening				
L	−29.45 ± 26.70	−34.00 ± 31.35	−12.06 ± 14.92	−13.99 ± 19.95
M	−175.46 ± 81.79	−148.92 ± 100.32	−126.99 ± 45.69	−117.07 ± 63.85
U_1	−8.30 ± 7.86	−10.31 ± 9.40	−3.87 ± 4.39	−4.62 ± 5.98
U_2	−4.99 ± 7.49	−4.52 ± 8.58	−3.63 ± 4.18	−3.46 ± 5.63
U_3	−15.80 ± 6.50		−3.15 ± 3.63	
Plant height at heading Vs Yield/plant				
L	19.78 ± 6.60	30.48 ± 5.04	6.24 ± 27.13	2.06 ± 34.87
M	2.83 ± 112.10	−51.63 ± 80.14	195.59 ± 83.06	216.86 ± 111.62
U_1	5.52 ± 10.78	9.65 ± 7.51	8.19 ± 7.98	6.57 ± 10.46
U_2	−2.17 ± 10.26	−3.15 ± 6.85	4.63 ± 7.60	5.01 ± 9.55
U_3	22.38 ± 8.92		−0.68 ± 6.60	
Plant height at ripening Vs Yield/plant				
L	34.45 ± 37.73	46.86 ± 6.92	69.27 ± 15.26	71.34 ± 20.23
M	212.58 ± 115.55	149.43 ± 22.13	122.59 ± 46.75	112.05 ± 64.73
U_1	5.39 ± 11.11	10.19 ± 2.07	9.80 ± 4.49	10.60 ± 6.06
U_2	2.77 ± 10.58	1.64 ± 1.89	4.34 ± 4.28	4.16 ± 5.54
U_3	24.80 ± 9.18		13.20 ± 3.71	

Table 5

Phenotypic (r_{ph}), genotypic (r_g) and additive (r_D) correlation between the different characters studied

	Toria-BP × Toria-A			Toria-TP × Toria-A		
	r_{ph}	r_g	r_D	r_{ph}	r_g	r_D
Heading date Vs Heading to ripening	−0.65	−0.68	−0.48	−0.74	−0.83	−0.51
Heading date Vs Plant height at heading	0.73	0.85	0.56	0.63	0.69	1.10
Heading date Vs Plant height at ripening	−0.94	−0.84	−0.35*	−0.94	1.10	−0.88
Heading date Vs Yield/plant	0.97	1.05	0.67	0.65	0.68	1.05
Heading to ripening Vs Plant height at heading	−0.89	−0.99	−0.41	−0.97	−0.97	−0.83
Heading to ripening Vs Plant height at ripening	0.71	0.82	0.81	0.87	1.46	1.06
Heading to ripening Vs Yield/plant	0.99	1.26	0.92	0.87	1.42	0.75
Plant height at heading Vs Plant height at ripening	−0.86	−0.97	0.05*	−0.52	−0.54	−0.15*
Plant height at heading Vs Yield/plant	0.11*	−0.02*	0.53	0.76	0.83	0.03*
Plant height at ripening Vs Yield/plant	0.94	1.12	0.70	0.89	0.96	0.79

* Non-significant values

magnitude, and all the five characters were found to be significantly correlated with yield and also amongst themselves, but the nature of the correlation was negative in five cases only. The presence of a significant correlation between fixable heritable components indicated that an early selection programme may be started for the improvement of these characters.

Additivity and dominance play an important role in the inheritance of quantitative characters in *Brassica campestris* L. and *B. juncea* L. (JOARDER—EUNUS 1968, 1970a, b, ZUBERI—JOARDER—EUNUS 1972). In the present investigation, however, only additivity was detected. Significant E_3 and non-significant E_1 in most of the cases indicated the presence of genotype–environment interaction in these characters. Both dominance and additivity interact with the environment in some of these characters (JOARDER—EUNUS 1976). Genotype–environment interaction may be responsible for the non-significant estimate of H (HILL 1966).

Estimated heritability values were high for most of the characters. Significant genetic gain along with a high heritability estimate are helpful in predicting the resultant effect of selection (JOHNSON—ROBINSON—COMSTOCK 1955). In the present study high heritability values accompanied by high genetic gain were mostly due to the additive effect (PANSE 1957) and show that phenotypic selection may be effective from an early generation.

Information derived from $\sqrt{(K_2D)}$ for possible selection advance indicates that trans-

gressive segregation in either direction may be expected for most of the characters studied. A similar expectation of transgressive segregation was reported by JOARDER—EUNUS (1970a, b) in segregating progenies of the crosses Toria-BP×Toria-7 and Toria-TP×Toria-7.

A comparative study of the estimates of K_1 and K_2 as to the number of effective factors conditioning the characters under investigation provides information regarding the sequence of arrangement of genes with plus and minus effects within the two parents. In cases where the plus and minus genes are not isodirectionally distributed within the parents, K_1 is under-estimated while the K_2 values remain unaffected (MATHER 1949). The fact that the estimates of K_2 were always more than those of K_1 in all the characters indicated that the genes are non-isodirectionally distributed in the parents. The K_2 estimate indicated the presence of 1 to 12 effective factors to control the characters studied. JOARDER—EUNUS (1970a, b) reported only one gene group (K_1) in this crop and considered that the low estimation of K_1 was due to the non-isodirectional distribution of polygenes in the parents. The presence of 1 to 19 dominant gene groups and 4 to 14 effective factors was reported to condition some of these characters in *Brassica juncea* L. and *B. campestris* L. respectively (JOARDER—EUNUS 1968, 1970a, b).

Tests for linkage could not detect the presence of linkage in most cases. From this, however, it cannot be said that there is no linkage operating, because the test fails to detect the presence of either very weak or very strong linkage. The presence of gene interaction has been reported by JOARDER—EUNUS (1970) and by ZUBERI—JOARDER—EUNUS (1972) in these characters. Different types of gene interaction effect D and H differently over generations as well as over ranks of statistics (HAYMAN—MATHER 1955, MATHER—JINKS 1971). Both linkage and gene interaction have been balanced in such a way that the test of linkage has failed to detect the presence of linkage in this study. A significant linkage in four cases indicated the heterogeneity of D and H over different ranks of statistics. None of the heterogeneity items are significant (Table 3), indicating that the heterogeneity of D and H over ranks of statistics is due to linkage. The values of D and H are different in V_{F_3} statistics than in others.

In covariance analysis the significant value of L indicates that some pleiotrophic effects are involved. The plus and minus signs of L indicate that the genes controlling the two quantitative characters are closely linked in the coupling and repulsion phases. The examination of the correlation coefficient indicated that there was a definite association between most of the characters. But in a few cases the inbred lines showed no association between some of the characters. The significant L may well be due at least to some extent to linkage. The positive significant value of M for the characters heading to ripening period and yield per plant for the cross Toria-TP×Toria-A, and for plant height at ripening and yield per plant for both the crosses indicated that the dominance of the two gene systems concerned is, on average, in the same direction. The examination of F_1 and F_2 means showed that the direction of dominance for these characters was towards higher performance. On the other hand, significant negative M values for the characters heading date and plant height indicated that the dominance of the two gene systems was in the opposite direction. Correlation studies revealed that heading date and plant height are positively correlated. This may arise due to linkage in the repulsion phase.

Plant breeders are in constant search of characters which are highly heritable and strongly correlated genetically. The characters studied were highly correlated genetically with the yield and amongst themselves and also exhibited high heritability and high genetic advance. All of these features suggest that a selection programme is likely to yield positive results towards higher yield. A high yielding early maturing variety of *Brassica campestris* L. is desirable in order to avoid pest attack, but the relatively high negative genotypic correlation between the heading date and the heading to ripening period indicates that it may be

difficult to produce such a variety. Covariance analysis indicated that the genotypic correlation was due to linkage, at least to some extent, and careful selection from the segregating progenies may give selection lines with a potential for high yield and early maturity.

*

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LIFE AND WORK OF JÓZSEF CSAPÓ

József Csapó was one of the most outstanding of the last Hungarian botanist physicians. He was born on 18th July 1734 in Győr (Hungary), son of József Csapó, legal adviser to Prince Eugene of Savoy, and Maria Ott, daughter of Christoph Ottius, a Swiss merchant from Schaffhausen. He received his elementary education in his native town, then attended higher educational institutions in Germany and Switzerland.

He became a doctor of medicine on 7th August 1759 in Basel. The degree of doctor was conferred on him by Johann Zwinger at the time when Johann Rudolf Stehelin was dean. According to the custom of the times Csapó held a discussion, without a chairman, on the Hungarian fever (*"Dissertatio inauguralis medica de febre Hungarica"*). He was the tenth Hungarian since 1576 to receive the degree of doctor at Basel University. It may be of interest to present this illustrious list: György Henisch 1576, Jakab Gregory 1586, Pál Gramer 1614, Keresztély Augustini ab Hortis 1620, János Kristóf Knogler 1656, Ferenc

Fig. 1. Portrait of József Csapó painted in 1775

Páriz Pápai 1674, Péter János Komáromi 1715, István Hatvani 1748, Gergely Dömök 1758 and József Csapó 1759.

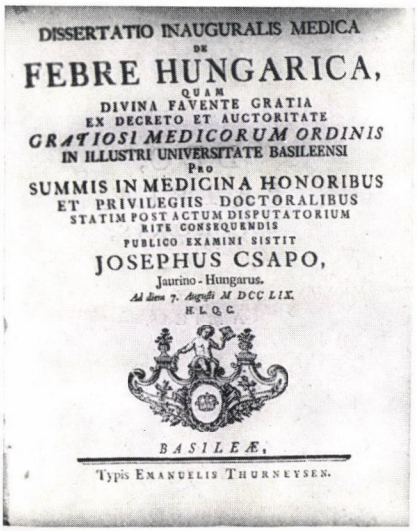
On his return home he was elected regular physician in Debrecen. He continued to work there until his death on 19th May 1799.

The era in which he worked. Csapó lived in a period characterized first by a colonial economic policy and then by an enlightened absolutism. In the economic policy developed after 1754 the Imperial Court of Vienna assigned the role of raw material production to Hungary. This state of dependence combined with the rigid feudal conditions had a paralysing effect on the economic and intellectual life of Hungary.

From the 1770's onwards it was increasingly realized that the Hungarian language, as it was then, was not suitable for the cultivation of sciences. Under the influence of the French enlightenment György Bessenyei (1747—1811) declares in his pamphlet "Jámbor szándék" (Good intentions) that science is the principal means of making a nation happy, while language is the first key to it, as no nation has ever been able to acquire wisdom until cultivating science in its own language.

It was thus during this period that Hungarian scientific literature evolved. János Molnár (1728—1804), physicist, writer and Jesuit teacher, rendered the terminology of physics into Hungarian in his book on physics published in 1777. Sámuel Rácz (1744—1807), physician and university professor, was a pioneer of Hungarian medical text-book literature. István Weszprémi (1723—1799), the other famous physician of Debrecen, founder of Hungarian medical history research, wrote the first Hungarian book for midwives in 1766.

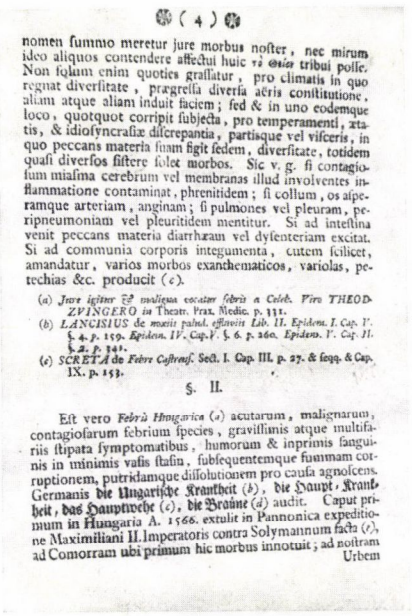
It is to this group of scientists that József Csapó belongs, whose book "Uj füves és virágos magyar kert" (New Hungarian lawns and flower-gardens), published in 1755, served to revive Hungarian botanical literature 200 years ago. The book he published in 1771 on pediatrics was the first work written on this subject in Hungarian.



DISSERTATIO INAUGURALIS MEDICA
DE
FEBRE HUNGARICA,
QUAM
DIVINA FAVENTE GRATIA
EX DECRETO ET AUCTORITATE
GRATIOSI MEDICORUM ORDINIS
IN ILLUSTRI UNIVERSITATE BASILEENSI
PRO
SUMMIS IN MEDICINA HONORIBUS
ET PRIVILEGIIS DOCTORALIBUS
STATIM POST ACTUM DISPUTATORIUM
RITE CONSEQUENDIS
PUBLICO EXAMINI SISTIT
JOSEPHUS CSAPO,
Jaurino-Hungarus.
Ad diem 7. Augusti M DCC LIX.
H. L. Q. C.

BASILEÆ,
Typis EMANUELIS THURNEYSEN.

Fig. 2. Frontispiece of *Dissertatio Inauguralis Medica* 1759



(4)

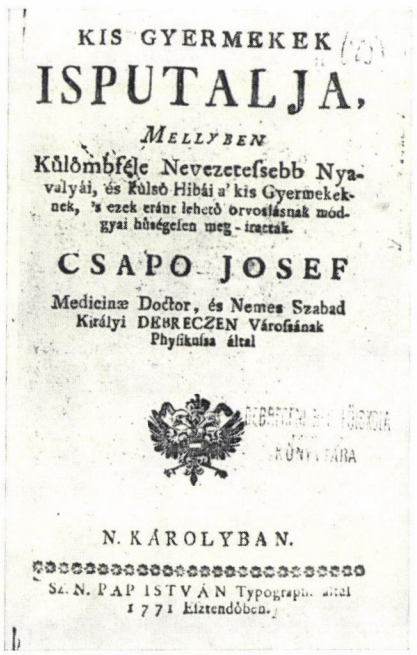
nomen ſummo meretur jure morbus noſter, nec mirum ideo aliquos contendere affectui huic τὸ ἐπίδημον tribui poſſe. Non ſolum enim quoties graſſatur, pro climatis in quo regnat diverſitate, prægreſſa diverſa aëris conſtitutione, aliam atque aliam induit faciem; ſed & in uno eodemque loco, quotquot corripit ſubjecta, pro temperamenti, ætatis, & idioſyncraſiæ diſcrepantia, partiſque vel viſceris, in quo peccans materia ſuam figit ſedem, diverſitate, totidem quaſi diverſos ſiſtere ſolet morbos. Sic v. g. ſi contagioſum miaſma cerebrum vel membranas illud involventes inflammatione contaminat, phrenitidem; ſi collum, os aſperamque arteriam, anginam; ſi pulmones vel pleuram, peripneumoniam vel pleuritidem mentitur. Si ad inteſtina venit peccans materia diarrhœam vel dyſenteriam excitat. Si ad communia corporis integumenta, cutem ſcilicet, amandatur, varios morbos exanthematicos, variolas, petechias &c. producit (c).

(a) *Juvat igitur Te malignam cocatæ febris a Celeb. Viro* THEODORO ZWINGERO *in* Theatr. Prax. Medic. p. 331.
(b) *LANCISIUS de motiis palud. effluviis Lib. II. Epidem. I. Cap. V. §. 4. p. 159. Epidem. IV. Cap. V. §. 6. p. 260. Epidem. V. Cap. II. §. 2. p. 341.*
(c) *SCRETA de Febre Caſtrenſ.* Sect. I. Cap. III. p. 27. & ſeqq. & Cap. IX. p. 153.

§. II.

Eſt vero *Febris Hungarica* (a) acutarum, malignarum, contagioſarum febrium ſpecies, graviſſimis atque multifariis ſtipata ſymptomatibus, humorum & inprimis ſanguinis in minimis vaſis ſtaſin, ſubſequentemque ſummam corruptionem, putridamque diſſolutionem pro cauſa agnoſcens. Germanis die Ungariſche Krankheit (b), die Haupt-Krankheit, das Hauptwehe (c), die Braune (d) audit. Caput primum in Hungaria A. 1566. extulit in Pannonica expeditione Maximiliani II. Imperatoris contra Solymannum facta (e), ad Comorram ubi primum hic morbus innotuit; ad noſtram Urbem

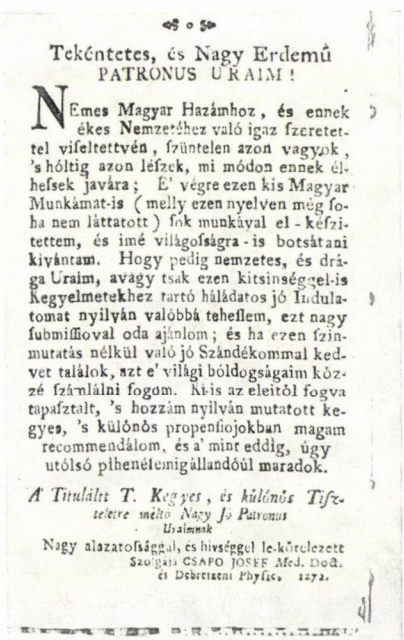
Fig. 3. Page 4 of *Dissertatio Inauguralis Medica*



KIS GYERMEKEK
ISPUTALJA,
MELLYBEN
Külömbféle Nevezetesſebb Nyavalyái, és Külsö Hibái a' kis Gyermekeknek, 's ezek eránt lehetö orvoſlásnak módgyai hüségeſen meg-iratnak.
CSAPO JOSEF
Medicinæ Doctor, és Nemes Szabad Királyi DEBRECZEN Városának Phyſikusa által.

N. KÁROLYBAN.
Sz. N. PAP ISTVÁN Typographus által
1771 Eſztendöben.

Fig. 4. Frontispiece of "Kis Gyermekek Isputalja" (Children's therapy) 1771



Tekéntetes, és Nagy Erdemü
PATRONUS URAIM!

NEmes Magyar Hazámhoz, és ennek ékes Nemzetéhez való igaz ſzeretettel viſeltettvén, ſzüntelen azon vagyok, 's hóltig azon léſzek, mi módon ennek élhetſések javára; E' végre ezen kis Magyar Munkámat-is (melly ezen nyelven még ſoha nem láttatott) ſok munkával el-készitettem, és imé világoſságra-is botsátani kiványtam. Hogy pedig nemzetes, és drága Uraim, avágy tsak ezen kitsinséggel-is Kegyelmetekhez tartó háládatos jó Indulatomat nyilván valóbbá tetſſem, ezt nagy ſubmiſſioval oda ajánlom; és ha ezen ſzinmutatás nélkül való jó Szándékommal kedvet találok, azt e' világi bóldogságaim közzé ſzámlálni fogom. Kis-is az eleitöl fogva tapaſztalt, 's hozzám nyilván mutatott kegyes, 's különös propenſiojokban magam recommendálom, és a' mint eddig, úgy utólsó pihenéſemigállandóúl maradok.

A' Titulált T. Kegyes, és különös Tiſztelettre méltó Nagy Jó Patronus Uraimnak

Nagy alazatoſsággal, és hivséggel le-kötelezett Szolgája CSAPO JOSEF Med. Doct. és Debretzeni Phyſic. 1772.

Fig. 5. Dedicatory lines in "Kis Gyermekek Isputalja" (Children's therapy)

Fig. 6. Frontispiece of "Uj Füves és Virágos Magyar Kert" (New Hungarian lawns and flower-gardens) 1775

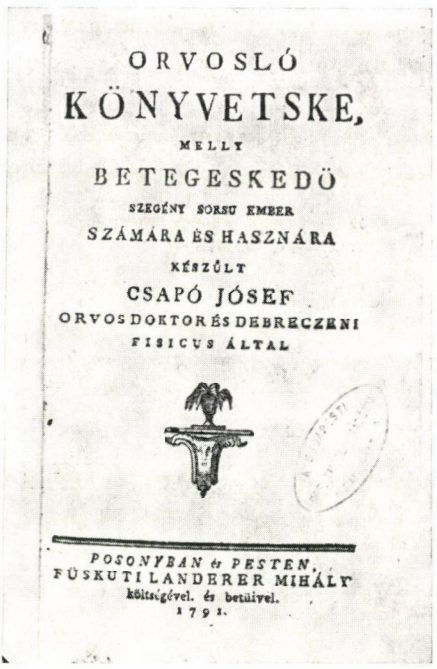


Fig. 7. Frontispiece of "Orvosló Könyvetske" (Hand-book of medication) 1791

Debrecen, the scene of Csapó's work. Prior to speaking of József Csapó's work let us first get acquainted in outline with the town he worked in. At the time of the 1784 census Debrecen, with 30,064 inhabitants, was the biggest town in Hungary. But in the opinion of an English traveller at the end of the century, it was perhaps the largest village in the whole of Europe. It is a fact that on 12th September 1770 the royal commissioner raised objections against the dirty streets and the lack of canalization. But even in 1798 the then royal commissioner is only known to have included canalization and grading work in Debrecen in his plans.

The devastation caused by the plague in the 18th century raised the idea of organizing the institutional nursing of the sick in Debrecen. The first building which served to receive the sick was established in about 1739, but no data on its functioning have survived.

At that time the intellectual life of Debrecen was active. One of its centres was in the house of István Weszprémi. Frequent guests here were János Földi (1755—1801), physician, naturalist, linguist and poet; Mihály Fazekas (1766—1828), poet and botanist; Mihály Csokonai Vitéz (1773—1805), the greatest poet of the Hungarian enlightenment, and Ferenc Kazinczy (1759—1831), poet, the leading figure of the contemporary literature and language reform. József Csapó probably belonged to this circle of scientists, as Weszprémi called him "my dear colleague" and "my kindred fellow-scientist" in his works.

"*New Hungarian lawns and flower-gardens*". The full title is "Új füves és virágos magyar kert, mellyben mindenik fűnek és virágnak Neve, Neme, Ábrázatja, Természete és Ezekhez képest külömbféle Hasznai, értelmessen meg-jegyeztettek Csapó Jósef medicinae doctor, és Nemes Szabad Királyi Debretzen Városának Physikussa által. Posonyban, Landerer Mihály költségével és betűivel. 1775" (New lawns and flower-gardens in Hungary

in which the name, genus, appearance, properties and various uses of each grass and flower are clearly noted by József Csapó, doctor of medicine and physician of Debrecen, royal free borough. Printed in Pozsony by Mihály Landerer at his own cost.) octavo 305 + 23. The second edition was published in the same place, 1792.

In this book Csapó described 417 plants of some importance in alphabetical order. Even if his data are not significant, the book itself is made highly significant by the fact that after Meliusz' Herbarium, published in 1578, and Beythe's *Stirpium Nomenclator Pannonicus*, 1583—4, this was the next botanical work written in Hungarian, after an interval of nearly 200 years.

Csapó tried to propagate botanical knowledge among those who did not know Latin. There were, in any case, problems with the Hungarian names of plants. Even in 1793, 19 years after Csapó's book was published, János Földi (1755—1801) mentioned in a pamphlet entitled "Rövid kritika és rajzolat a magyar füvésztudományról" (A brief criticism and delineation of Hungarian botany) that the names of plants were not uniform. In Földi's opinion this caused confusion and made most of the Hungarian medical and agricultural books useless.

For this very reason it is noteworthy that Csapó recorded all the Hungarian names used in practice for each plant. At the end of the first edition he noted that he had listed 646 Hungarian names for 417 grasses. In the second edition the number of Hungarian plant names exceeds a thousand.

In his work he relied on Crantz's book (*Institutiones rei herbariae juxta nutum naturae digestae exhabitu.* Viennae, 1766), but he was also acquainted with Meliusz, Beythe and Clusius' "Pannonian flora".

The names of the 417 plants listed in alphabetical order are given in Hungarian, Latin, French, German and Italian. The descriptions are deficient, but detailed information is given on the internal and external uses of the plants. Apart from this his data bear witness to his thoroughness as a botanist. He collected plants in the neighbourhood of Debrecen, in Szatmár, Győr, Veszprém, Fejér, Somogy and Baranya counties and in the Bakony hills.

He himself invented plant names. He wrote: *Stratiotes aloides* L. "Koloka. Imergyökér. (Water-soldier.) Latin: *Imera pannonica.* (This name has been invented by Csapó.) This spiky-leaved aquatic grass grows in a lake in Veszprém county. It is a highly poisonous grass, soon causing the death of people and animals." (p. 140)

In his book "Magyar ritkaságok" (Hungarian rarities) Béla Tóth wrote that paprika was first mentioned by its present name in Csapó's book. In the relevant Hungarian literature it was first mentioned in Albert Szenczi Molnár's dictionary, published in 1604, under the name "Turkish pepper, piper indicum". Csapó also mentioned this name, and in addition called it garden pepper, or paprika.

Csapó's botanical work seems to have aroused interest in others. His work became widely known, as proved by the second, unrevised edition published in 1792. In Debrecen Csapó's botanical work was continued by Samuel Diószegi (1760—1813), botanist, pastor and teacher, who published the "Magyar Füvészkönyv" (Hungarian botanical book) in 1807 and the "Orvosi Füvész Könyv" (Medical Botany) in 1813, both in Debrecen.

Other works by József Csapó. 1. *Disquisitio de praesentia liquidi nervi in musculo . . .* Argentorati, 1756. octavo 1 page.

2. *Problema Theoreticum de auditu et Practicum de Pleuritide.* Basiliae, 1758. quarto 11 pages.

3. *Dissertatio inauguralis medica de febre Hungarica.* Basiliae, Typ. Emanuelis Thurneysen. 1759. quarto 26 pages.

One paragraph might perhaps be quoted from this doctor's dissertation, in which Csapó defines his subject as follows: "Hungarian fever is a type of acute, malignant, infectious

fever which is accompanied by very severe symptoms in many places; stagnation and consequent decay and rotting in the tiniest lymphatic and blood vessels have been found to be the causes. In German it is known as 'Hungarian disease' b) 'head disease, headache' and c) 'croup, sore throat'. d) In Hungary it first appeared in 1566, in the Pannonian military expedition of Emperor Maximilian II against Suleiman, e) where this disease first became well-known at Comorra."

4. "Kis Gyermekek Isputalja . . ." (Children's therapy, in which major diseases and external disorders of small children and their possible therapy are precisely described by József Csapó, doctor of medicine and physician of Debrecen, royal free borough). Nagykároly. Sz. N. István Pap Typograph. 1771. octavo X + 122 pages.

As we have mentioned, this was the first pediatric work written in Hungarian, and was reviewed, according to Weszprémi, in Part XIII of the 1771 Vol. of *Ephemerides litterariae Vindobonenses*. It was also reviewed by Prof. Tibor Győri in No. 1903/3 of the "Orvosi Hetilap" (Medical Weekly).

5. "Orvosló Könyvetske . . ." (Hand-book of medication, intended for the use of the poor sick, by József Csapó doctor of medicine, physician of Debrecen, printed in Pozsony and Pest at the expense of Mihály Füskuti Landerer. 1791. octavo 382 pages.

6. *Valetudinarium infantile Hungaricum novum sistens morbos infantium centenos horumque tutos curandi modos . . .* Pestini, 1794. octavo VIII + 188 pages. (The manuscript, dated Debrecen 1791, is in the Hungarian National Museum.)

7. A work in manuscript "Über zusammen-gewachsene Kinder. 1791" is in the Hungarian National Museum.

Evaluation of József Csapó. His books and the abundant references found in them are a speaking illustration of the high level of his scientific knowledge. This is made particularly clear by the list of books left behind after his death. (In the Hajdú-Bihar County Archives: "*Conscriptio Librorum Dni Josephi Csapó quandam L. R. Cittis Debrecziensis Ord Physici.*" Registry number: Relatio IV A 1011/k—1800/117. His library is listed on nine pages, under serial numbers 1 to 226.)

It would be well worth processing and reviewing this list of books even from the point of view of cultural and literary history. Naturally, it can only be mentioned here in a few sentences. Csapó's oldest book was Filep Melanchton's "*Filosofia moralis*", dated 1530. He had a medical book from the 16th century: "*Valesco de Taranta Filonum Pharmaceuticum et Chirurgicum.* Francofurti 1599."

Among the 226 books there are four works written in Hungarian: a Bible published in 1608, in Hannover, translated by Albert Szenczi Molnár; Ferencz Miskolczi: "Chirurgia Uti Társ" (Chirurgical travelling companion), Győr, 1742; János Lang: "A Magyar Országi Orvos Vizekről való Könyv" (Medical waters in Hungary), Nagykároly, 1783; "Orvosi Tanítás a Gyermekek Nyavalyáik megesmeresekről" (Diagnostics of children's diseases), Pest, 1794.

His enlightened mind and his love for the nation are clearly reflected in his life-work. As he himself wrote, his "Hand-book on medication" was published to enable the poor sick of the Hungarian plains to cure themselves with the grasses and flowers found everywhere. This shows his advanced way of thinking and readiness to help, as well as his sense of responsibility and love for his nation, even though the poor people of the Hungarian "puszta" were probably the least able to buy and read his book.

We must not forget that in the 1780's nearly half of the Hungarian villages had no schools. The peasantry lived in adobe or mud houses under unhealthy conditions. Therefore all those who did anything to make people's life more human are worthy of special attention. To this group belonged József Csapó, whose life and work are dealt with in this brief review, prepared on the occasion of the 200th anniversary of the publication of his botanical work.

P. HARGITA

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THE INFLUENCE OF HARVESTING TIME AND NUMBER OF PLANTS PER HILL ON YIELD OF ROOTS AND SUGAR IN SUGAR BEET

Although sugar beet (*Beta vulgaris* L.) is a main sugar crop in the world, there is very little information available in the Arab Republic of Egypt regarding the effect of different cultural methods on the yield and sugar content of this crop.

Extensive studies on the time of planting and harvesting of sugar beet have been conducted in many countries. PANTANELLI (1948) pointed out that sugar beet cultivation could be successful in many Mediterranean regions where sowing took place in November and the crop was harvested in May. MUSILLAMI (1960) reported that the best time for sowing in Sicily was early December and the best harvesting time was 1—20 July. MIAN (1966), in the Pashawar Valley, stated that the highest root yields were obtained if the crop was harvested in June. Studies conducted by NODA *et al.* (1961), HALL—HILLS (1962) and DRAYCOTT *et al.* (1973) indicated that a delay in the harvesting time increased the average yields in sugar beet.

BROADHEAD *et al.* (1963) stated that hill treatments required less seed for the planting and less labour for the thinning, cultivation and harvesting of sugar beet. SCHROTER (1965) indicated that the proportion of light-weight roots increased as the number of plants per hill increased, but he reported no differences in their sugar content. BIRNEY (1946), ROBINSON—WORKER (1969) and DRAYCOTT *et al.* (1971) studied the effect of planting densities on the yields of roots and/or sugar in sugar beet. They reported on different populations and found that increases in the yield and sugar content of the roots varied according to the population tested and the variety under investigation.

The objective of the present investigation was to obtain information regarding the effect of the planting season, time of harvesting the crop and the optimum number of plants per hill on the total yields of fresh roots and sugar per hectare.

The sugar beet variety tested was A.J.4, which was imported from Poland. Planting was carried out over two seasons. The summer planting was seeded on April 18th 1972, while the winter planting was seeded on December 1st 1973. Six seeds were planted in each hill. 60 days after planting, thinning to one, two, three and four plants per hill was carried out.

The experimental design was a strip-plot with three replications in the summer planting and four replications in the winter sowing. Plot size was 3.0×3.5 m and each plot consisted of rows 3.0 m long and spaced 50 cm apart. The distance between hills was 20 cm for all treatments. Other cultural practices such as fertilization, irrigation and weeding were conducted in a uniform manner. All the test plots were planted on a clay loam soil at the Al-Azhar University Farm near Cairo.

Harvesting dates tested were 165, 180, 195 and 210 days from planting. At harvest,

the plants from each hill were hand dug, knocked, correctly topped, cleaned and then weighed to give the fresh weight of the roots. Samples from each plot were taken at random in order to determine the sucrose content in the roots. Total yields of fresh roots and sucrose per hectare were calculated.

Analysis of variance was carried out on the field and laboratory data according to standard procedures for factorial experiments.

Fresh roots per hectare. The mean weights of fresh roots, in tons per hectare, are presented in Table 1. Delaying the harvest considerably affected the fresh root yield in both the summer and winter seasons. Harvesting after 210 days from planting exhibited the greatest increase in yield.

The effect of the number of plants per hill on the yield of fresh roots was significant in summer planting and the highest yield was obtained when four plants per hill were left to grow. However, in winter sowing there was a non-significant reduction in yield as the number of plants per hill was increased.

The interaction between the harvesting date and the number of plants per hill was only significant in summer planting and the highest yield of fresh roots was observed when four plants per hill were grown and the crop was harvested after 195 days (Table 3).

It is evident from the data presented (Table 1) that the average yields obtained from crops planted in winter were always higher than those obtained in the summer seeding.

Sugar yield per hectare. Table 2 shows that the harvesting date had a significant effect on the sugar yield. In the summer season, the sugar yield increased as the harvesting time was delayed to 195 days from planting. Further delay in the harvesting date significantly reduced the sugar yield. Results of the winter season indicated that the yield of sugar per hectare was increased by delaying the harvesting date to 195 days, but no further increases were observed when the plants were harvested after 210 days from planting.

The number of plants per hill significantly affected the sugar yield in both the planting seasons (Table 2). Increasing the number of plants per hill from one to two plants significantly increased the sugar yield. However, in summer planting, no significant increases were obtained as the number of plants per hill was raised to three or four plants, whereas in winter seeding a significant reduction in the yield of sugar was obtained when the number of plants per hill was increased to four plants.

The interaction between the harvesting date and the number of plants per hill was significant (Table 3), indicating that the total yield of sugar per hectare was influenced by the two factors tested. The maximum sugar yield was achieved in summer planting when four plants per hill were grown and harvested after 195 days. In winter seeding, the highest yield of sugar was obtained when two plants per hill were left to grow and then the crop was harvested after 210 days from planting.

Although the data collected in each planting season have been separately analysed, it was evident that planting sugar beet in December (winter season) gave relatively higher yields of fresh roots and sugar per hectare than the April seeding (summer season). The results presented support conclusions previously reported by PANTANELLI (1948) and MUSILLAMI (1960).

The weather conditions prevailing during the growth of sugar beet, particularly temperature (BRUMMER 1961), light intensities (DOTZENKO—ARP 1972) and day-length (YUNOMURA *et al.* 1962) have a considerable influence on the productivity of the crop. It may be presumed that after the first period of growth, in winter sowing, the temperature was moderately increased and the days became longer, which encouraged the crop photosynthesis. On the other hand, in April seeding, the decreased yields of roots may be due to the decrease in the ratio of photosynthetic activity to respiration as the crop grows under lower temperature and shorter days, which gave inferior yields in comparison to winter planting.

Table 1

Mean yields of fresh roots, in tons per hectare as affected by harvesting date and number of plants per hill

Number of plants per hill	Summer planting					Winter planting				
	Days of growth before harvest					Days of growth before harvest				
	165	180	195	210	Mean	165	180	195	210	Mean
1	10.905	21.467	17.874	29.896	20.036	28.323	43.475	50.094	68.526	47.605
2	18.801	23.051	29.680	24.935	24.117	28.244	41.956	53.406	65.909	47.379
3	16.382	22.601	32.138	27.968	24.772	26.089	42.991	49.723	63.945	45.687
4	13.525	30.141	35.710	30.035	27.353	28.402	43.812	49.999	61.018	45.808
Mean	14.904	24.315	28.851	28.209	24.069	27.765	43.059	50.806	64.849	46.620

Table 2

Mean yields of sugar, in tons per hectare as affected by harvesting date and number of plants per hill

Number of plants per hill	Summer planting					Winter planting				
	Days of growth before harvest					Days of growth before harvest				
	165	180	195	210	Mean	165	180	195	210	Mean
1	0.574	2.408	3.013	0.740	1.648	1.478	3.449	3.947	3.395	3.067
2	1.429	1.339	3.848	1.436	2.013	2.804	3.919	4.059	7.643	4.606
3	0.871	2.499	4.003	1.332	2.176	1.775	3.233	5.758	5.517	4.071
4	0.765	1.701	5.045	0.693	2.051	1.886	4.129	4.536	3.634	3.546
Mean	0.910	1.987	3.977	1.050	1.981	1.986	3.683	4.575	5.047	3.823

Table 3

Analysis of variance for yields of roots and sugar in the two planting seasons

Source of variation	D. F.	Summer planting Mean of squares		D. F.	Winter planting Mean of squares	
		Root yield	Sugar yield		Root yield	Sugar yield
Harvesting dates	3	503.21**	23.99**	3	3829.28**	29.12**
Error (I)	6	1.48	0.010	9	160.95	1.13
Number of plants per hill	3	108.15**	0.54**	3	17.02	7.05**
Error (II)	6	2.62	0.04	9	56.50	0.61
Har. × N. plants interaction	9	52.59*	1.12**	9	14.27	4.42**
Error (III)	18	1.22	0.03	27	79.69	0.43

* Significant at the 5% level of probability.
** Significant at the 1% level of probability.

It is recognized, however, that the longer the period the crop stayed in the field, the higher the yields of fresh roots obtained, regardless of the planting season (Table 1). This could be attributed to the fact that increases in the yield of the roots are primarily due to the increased photosynthetic products which the plant stores in its root. Hence, the longer period of growth tested before harvest allowed more time for the accumulation of such deposits. These findings confirm results reported by NODA *et al.* (1961), HALL—HILLS (1962) and MIAN (1966), that delaying the harvest increased the yield of the roots.

The results obtained in this study concerning sugar yield per hectare show clearly that, in summer planting, lengthening the growing period at first increased the yield of sugar, then it declined as the time of harvesting was delayed to 210 days. The reduction observed at the latest date of harvesting adds more support to the conclusion that the low temperature and short day-length prevailing during the months of November and December in the Arab Republic of Egypt might have decreased the photosynthetic activity and therefore reduced the accumulation of sugar in the roots. On the other hand, the crop planted in winter was subjected to better conditions, which encouraged the photosynthetic activity, and more sugar was deposited in the roots as the time of harvesting was delayed.

Although the effect of seasonal climatic changes on the physiology and morphology of the sugar beet plant at the various periods of growth would be a very complex study, the results obtained suggest that the environmental conditions prevailing after planting in April were unfavourable for increasing the yields of fresh roots and sugar. But winter planting and a delayed harvesting time was the most suitable for achieving the highest yields.

Planting sugar beet in hills requires less seed and labour (BROADHEAD *et al.* 1963), which reduces the expenses of production. On the basis of evidence produced during the present investigation, the influence of the number of plants per hill and, accordingly, the total population grown per hectare on the yield of fresh roots and sugar differed with the growing season. Small beets were reported by SCHROTER (1965) as the number of plants per hill was increased. Competition for light and nutrients between plants of the same hill must have been the reason for the production of these smaller beets. Since the conditions facing the crop planted in winter were in favour of larger beets (Table 1), it is therefore expected that competition between plants caused the different responses to the growth season. This is in agreement with the results presented by LOOMIS—ULRICH (1962) that the size of the roots was varied by varying the planting date.

The greatest yield of sugar per hectare was achieved when two plants per hill were left to grow. However, no significant increases were observed in summer planting, but a significant reduction was obtained in the yield of sugar per hectare when four plants per hill were grown in winter. ULRICH (1959) reported that gross sugar per pot increased when the number of plants was raised from one to two per pot and thereafter remained relatively constant as the plants per pot were increased to four plants. The reduction in sugar yield despite the high yield of roots per hectare in the winter sowing would suggest that higher amounts of sugar must have been consumed by the plants through the warm nights of the summer months, which the plants were not able to compensate for due to the competition for light as the number of plants per hill was increased.

It seems reasonable to conclude that under the prevailing environmental conditions, the planting of sugar beet should be carried out in winter and the crop should be harvested 195 days after planting. In order to reduce the expenses of production, two plants per hill should be left to grow.

*

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CHANGES CAUSED BY CARBAMATE-TYPE COMPOUNDS IN THE EPICOTYL TISSUES OF BEANS (PHASEOLUS VULGARIS L. CV. KINGHORN WAX)

Carbamate-type herbicides have been found to check to some extent the amylase activity, to act antimitotically on the growing tips and to inhibit photosynthesis (SCHNEIDER 1974, ANONYMOUS 1971).

At our institute the biological activity of a number of carbamate-type compounds, similar to asulam, produced by the CHINOIN Chemical and Pharmaceutical Works, was studied in various plant species.

Of the group, Asulox* and MKF 790 had the greatest effect on the test plants after pre-emergence application. It was remarkable that in beans — besides other symptoms of damage — the external habit of the epicotyl also changes (becoming thicker and bent). For this reason an intensive analysis of the epicotyl tissues was made.

The beans were sown in a greenhouse in $14 \times 12 \times 5$ cm plastic pots filled with washed Danube sand, and the herbicides (5.9 mg/ml and 23.6 mg/ml water per pot) were sprayed on at the time of sowing. Histological observations were made on plants given the smaller dose.

On the 21st day after treatment test material from the middle of the epicotyl was fixed in a mixture of formalin–glacial acetic acid–50% ethanol (90 : 5 : 5), dehydrated with tertiary butyl alcohol and embedded in paraffin. The following treatments were carried out on 14 μ sections: *a)* staining with a 1% solution of alcohol–soluble nigrosin, and mounting in aqueous glycerine (KISSER—HALBWACHS 1972); *b)* staining with rubeane–hydrogen acid and mounting in Canada balsam (KISSER—HALBWACHS 1972; nigrosin does not stain the pectine, while in sections pre-treated with cupric salt the pectine alone turns black under the influence of rubeane–hydrogen acid. By the use of these two staining methods the qualitative differences in the pectine content can be demonstrated); *c)* the preparations were made after JENSEN (1962) with the modification that the slides were kept for 8 hours either in 0.5% ammonium oxalate solution or in 4% sodium hydroxide solution. Sections stained with periodic acid–Schiff (PAS) reagent were mounted in Canada balsam and measured cytophotometrically. For the purposes of cytophotometry, sections were prepared from 5 plants each; the transmission of the cell-wall was measured at 4 points on each of 5 collenchyma cells at 650 nm.

JENSEN—ASHTON (1960) studied the cell-wall polysaccharides in onion root tips. They stained the sections with PAS reagent. Periodic acid is known to oxidize the primary and secondary alcohol groups into aldehydes and is thus suitable for the cell-wall too (DRING 1955, JENSEN 1962). Since pectine and hemicellulose have different solubilities, after the extraction of the pectine, then of the hemicellulose, the staining of the cell-wall will be fainter.

During extraction, the cell-walls swell. Since there is a change in the colour intensity of the cell-wall after the pectine and hemicellulose have been extracted, we wanted to express this change numerically, thereby eliminating the subjectivity of Jensen's method, where photos were taken of the preparations and then compared. The most suitable technique for our purpose seemed to be cytophotometry, used in cytology, with which we measured the light transmission of the cell-wall. The measurements were carried out at 650 nm, because it was at this wave-length that transmission in the stained control was the most intensive. It should be noted that the mounting medium may modify to some extent the place of maximum transmission; e.g. when polyvinyl-alcohol is used for mounting (GERLACH 1969) the colour of the preparation will be different than with Canada balsam.

* Containing 40 per cent asulam (methyl-(4-amino-benzol-sulphonyl)carbamate) as active agent.

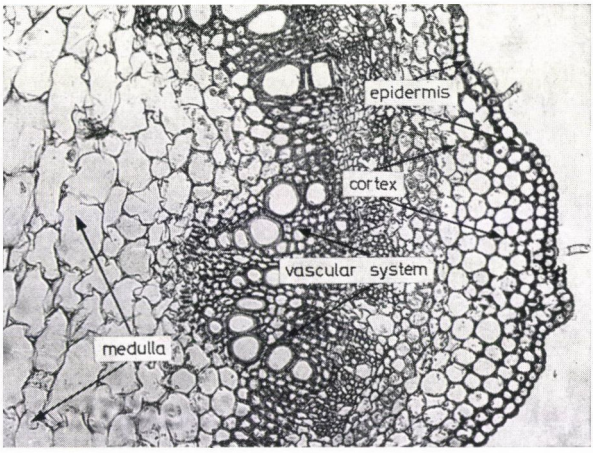

Fig. 1. Epicotyl cross-section of control bean stained with rubeane-hydrogen acid (×63)

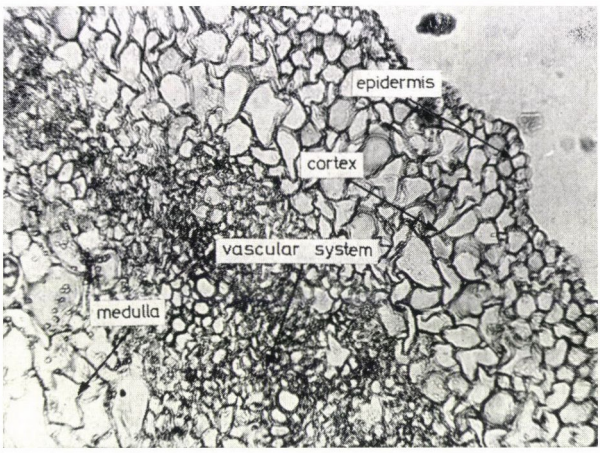

Fig. 2. Epicotyl cross-section of Asulox-treated bean stained with rubeane-hydrogen acid (×63)

Asulox and MKF 790 inhibit the growth of beans to an extent depending on the rate of application. This is also reflected in the formation of the epicotyl tissues. In the control the conducting and supporting tissues are well developed (Fig. 1); in the treated plants, on the other hand, the development of these tissues is insufficient, while the parenchyma cells of the cortex and medulla become larger and their cell-walls thinner (Fig. 2). The angular collenchyma of the cortex above the large bundles characterizing the bean plant is missing in the herbicide-treated plants.

A thorough investigation was made into changes in the components of the cell-wall (Cook—Stoddart 1973) in order to discover whether there was any change in the polysaccharides of the cell-wall.

It was observed that in the angular collenchyma of the control bean plants the pectine was found in the middle lamella and in the angles (Fig. 3). Under the influence of Asulox and

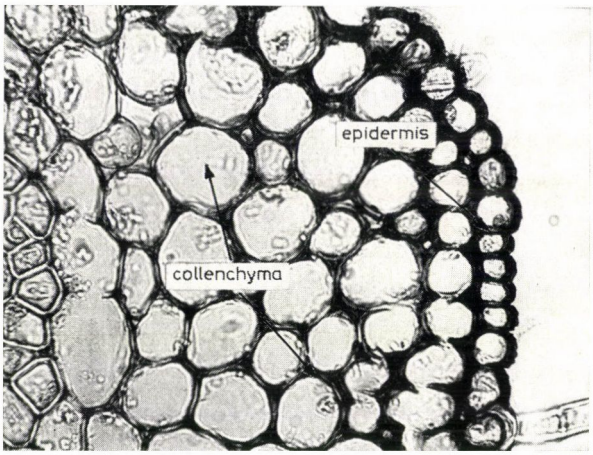

Fig. 3. Epicotyl cross-section of control bean stained with rubeane-hydrogen acid (×397)

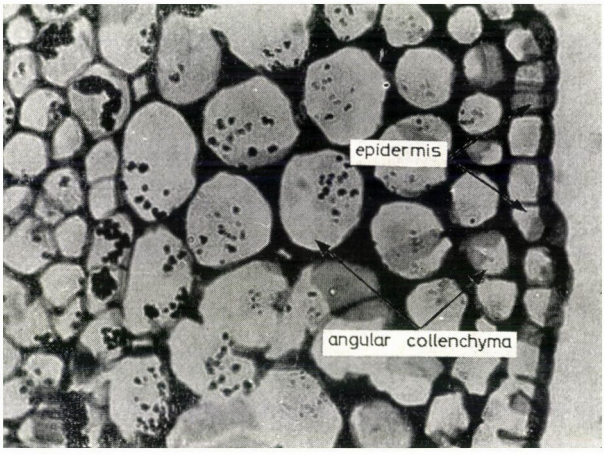

Fig. 4. Epicotyl cross-section of control bean stained with PAS (×378)

MKF 790 cell-wall thickening did not occur. After staining the sections with rubeane-hydrogen acid, blackening was only seen between adjacent cells, and not in the angles, which suggested that pectine was only found in the middle lamella.

Figs. 4 and 5 show cross-sections of the epicotyl of the control beans (Fig. 4 shows cross-sections stained when unextracted and Fig. 5 shows those stained with PAS reagent after the pectine had been extracted).

The results of the measurements are summarized in Table 1.

In the control plants the collenchyma has developed, therefore the cell-wall shows a low rate of transmission. Under the influence of treatment with carbamate-type compounds, since no cell-wall thickening occurred the transmission of the cell-wall is higher. If the pectine is extracted, transmission increases, to the greatest extent in the control plants. Further treatment with a 4% solution of sodium hydroxide to extract the hemicellulose did not cause any substantial difference in transmission. Thus, differentiating staining and cyto-

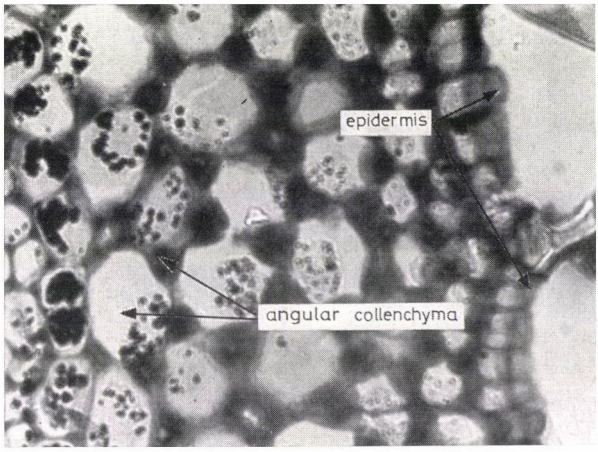

Fig. 5. Epicotyl cross-section of control bean stained with PAS after extraction of the pectic substances (×378)

Table 1

Transmission values in the collenchyma cells of bean epicotyl

	Without extraction	Transmission values	
		After extraction of pectic substances	After extraction of pectic substances and hemicellulose
Control	38.5	74.2	73.1
Asulox	54.0	65.4	71.6
MKF 790	45.5	63.3	61.1
LSD at the 5% level	6.58		

photometry both prove that under the influence of Asulox and MKF 790 the angular collenchyma fails to develop in the cortex of the epicotyl of beans, and a change occurs in the ratio of cell-wall polysaccharides.

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CORRELATIONS AND FACTOR ANALYSIS OF FODDER YIELD COMPONENTS IN COWPEA

Cowpea *Vigna unguiculata* (Linn.) Walp., syn. *V. sinensis* (Linn.) Savi. is mostly used as a grain crop in Africa and the Middle-East, grain-cum-vegetable or grain-cum-fodder crop in India, and grain, vegetable, forage, and soilbinding crop in North America and Australia. The Indian subcontinent and Africa have been considered as the probable centres of origin of the cowpea (FARIS 1965). Once brought under cultivation in these regions of the world, the cultivars further evolved into different ecotypes, depending on the natural and artificial selection pressures, applied in favour of the specific usage and adaptability of the crop. Cultivars from these diverse regions were assembled at this Institute, for use in a breeding programme aimed at the development of high yielding and nutritive forage cowpea varieties. When evaluated under a uniform environment, the cultivars obtained from these regions differed in fodder yield and other production traits (MEHRA *et al.* 1970). Inter-regional comparisons also revealed differences in the heritability and expected genetic gain of the various fodder yield components (KOHLI *et al.* 1971). Nothing is known about the associations between the various fodder yield components. In fact, information on the nature and extent of genetic associations among the various fodder yield components would help to formulate and improve the efficiency of the selection criterion through the use of a favourable combination of characters and also to minimize the adverse effects of those characters which show negative correlations with fodder yield. Furthermore, such information taken separately in the divergent genotypes from different agroclimatic regions of the world would ostensibly express the stability of the genetic associations of fodder yield with other morphological characters. This information would further help in the choice of the material for use as parents in a hybridization programme aimed at the development of suitable varieties possessing a specific combination of desirable fodder yield components. The results of a study undertaken to assess and compare the nature and extent of correlations amongst the various fodder yield components of cowpea cultivars obtained from five distinct regions of the world are presented in this paper.

One hundred and fifty-four cultivars (Far-Eastern = 16, Indian = 45, Middle-Eastern = 20, African = 35 and U.S.A. and Latin American = 38) were randomly selected from 1072 cowpea cultivars maintained at the Indian Grassland and Fodder Research Institute,

Jhansi. The varieties were grown under a uniform environment in a randomized block design, for each region separately, using four replications each. Each variety was sown in a single row, 3 m long and with distances of 1 m and 15 cm respectively between the rows and plants.

The observations on plant characters were recorded on three randomly selected plants of each variety in each replication, as follows; 1. Days to flower, number of days from planting to flowering; 2. Plant height (cm), measured from the ground to the tip of the main stem; 3. Main branch length (cm), measured from the base to the tip of the best developed primary branch; 4. Number of primary branches, counted on the main stem; 5. Stem girth (cm), measured on the thickest internode of the main stem; 6. Number of leaves, counted on the entire plant; 7. Green weight (g), individual plants weighed immediately after the harvest; 8. Dry weight (g), individual plants dried and weighed.

The analysis of variance, covariance and estimates of simple correlation coefficients were computed (GOULDEN 1954, PANSE—SUKHATAME 1961). The environmental and genotypic correlation matrices were subjected to the centroid method of factor analysis (HOLZINGER—HARMAN 1941, MAXWELL 1961), using the highest correlation coefficient in each array as an estimate of the array communality (CATELL 1965).

FISHER's (1938) Z statistics were used for the computation of χ^2 values for the test of heterogeneity of correlation coefficients over the five regions.

1. *Correlation.* The phenotypic, genotypic and environmental correlation coefficients between the individual fodder yield components and also between them and the fodder yield are presented regionwise separately in Table 1.

A) *Far-Eastern material.* The phenotypic correlations between the eight characters studied were significant and positive, although the degrees of such correlations varied between different character combinations. The genotypic correlations between these characters were also positive and high. The environmental correlations between the different character combinations were also significant and positive except those between (i) the days to flower and all other characters; (ii) the plant height and all characters except the number of primary branches and number of leaves and (iii) the dry weight and the number of primary branches and stem girth.

B) *Indian material.* Significant and positive phenotypic and positive genotypic correlations were observed between all character combinations studied, except those between the number of primary branches and the days to flower, plant height and dry weight. The environmental correlations were also significant and positive between the different character combinations except those between (i) the days to flower and all other characters except the plant height and dry weight and (ii) the plant height and the number of primary branches and stem girth.

C) *Middle-Eastern material.* The phenotypic and environmental correlations were mostly significant and positive between all character combinations studied except those involving the plant height. At the genotypic level, while the correlations between all character combinations were positive and mostly high, the plant height was negatively correlated with the number of primary branches, stem girth, number of leaves, green weight and dry weight. Similarly, the environmental correlations of the plant height were significant and positive with the main branch length, stem girth and dry weight.

D) *African material.* The phenotypic correlations were significant and positive between all character combinations studied except those between (i) the number of primary branches and the days to flower and plant height and (ii) the stem girth and the days to flower and main branch length. The genotypic correlations were high and positive in all combinations between the days to flower, plant height, main branch length, number of leaves, green weight and dry weight. The number of primary branches was also correlated positively at the genotypic level with the days to flower, main branch length, number of leaves and green weight. The

Table 1

Phenotypic (P), genotypic (G) and environmental (E) correlation coefficients among eight characters in cowpea cultivars from different regions

Character combinations*		Correlation coefficients in cultivars from				
		Far-East	India	Middle-East	Africa	America
		1	2	3	4	5
1 2	P	0.4153**	0.5267**	0.0275	0.3196**	0.3001**
	G	0.7745	0.9079	0.3846	0.5827	0.6746
	E	0.0919	0.2574**	0.1577	0.2034*	0.2031*
1 3	P	0.6929**	0.4518**	0.5068**	0.4614**	0.5189**
	G	1.0071	0.8499	0.4971	0.7946	0.7258
	E	0.1695	0.1836	0.5242**	0.2835**	0.4325**
1 4	P	0.5197**	0.1030	0.3940**	0.9400**	0.3696**
	G	0.9629	0.1647	0.6389	0.8297	0.3718
	E	0.0114	0.0825	0.2744*	0.0254	0.3712**
1 5		0.3903**	0.2800**	0.4793**	0.0372	0.3948**
	G	0.6436	0.5673	0.7257	0.0658	0.7430
	E	0.0589	0.0796	0.3533**	0.0990	0.2561
1 6	P	0.6698**	0.3546**	0.4396**	0.4188**	0.5136**
	G	1.0004	0.8040	0.3777	1.0984	0.5132
	E	0.0500	0.1409	0.4636**	0.1553	0.5174**
1 7	P	0.6752**	0.3619**	0.4966**	0.3801*	0.5161**
	G	1.0105	0.8402	0.8088	0.8537	0.7334
	E	0.0361	0.1420	0.3936**	0.1570	0.4451**
1 8	P	0.7268**	0.5587**	0.7103**	0.5382**	0.6197**
	G	1.0335	0.9605	1.0574	1.1316	1.0655
		0.2081	0.3596**	0.6392**	0.3167*	0.5191**
2 3	P	0.5213**	0.6685**	0.1794**	0.3908**	0.4410**
	G	1.0176	0.8931	0.0333	0.4018	0.3624
	E	0.1210	0.4493**	0.2900*	0.3877**	0.4930**
2 4	P	0.5247**	0.0409	0.1001	0.0531	0.2257*
	G	0.8545	0.0288	0.2989	0.0862	0.0278
	E	0.3142*	0.0803	0.0514	0.0512	0.3138**
2 5	P	0.4264**	0.3740**	0.1222	0.2676**	0.3410**
	G	0.6696	0.5540	0.1299	0.1767	0.1871
	E	0.2611	0.1927	0.3489**	0.3235**	0.5220**

Character combinations*		Correlation coefficients in cultivars from				
		Far-East	India	Middle-East	Africa	America
		1	2	3	4	5
2 6	P	0.6496**	0.4785**	0.0261	0.4336**	0.3998**
	G	0.9380	0.7759	0.0923	0.5929	0.2177
	E	0.4291**	0.2968**	0.0919	0.3753**	0.4696**
2 7	P	0.5525**	0.4397**	0.1060	0.5266**	0.4164**
	G	0.9223	0.7687	0.2022	0.9372	0.0503
	E	0.2425	0.2444**	0.2567	0.3426**	0.5147**
2 8	P	0.5207**	0.5484**	0.1382	0.5313**	0.4931**
	G	0.8841	0.8572	0.3321	0.7062	0.5852
	E	0.2329	0.3495**	0.3111*	0.4699**	0.4758**
3 4	P	0.7599**	0.2528**	0.5871**	0.3121**	0.7597**
	G	0.2878	0.2308	0.7663	0.7566	0.8546
	E	0.5335**	0.2805**	0.4491**	0.2592**	0.7072**
3 5	P	0.5464**	0.5210**	0.6079**	0.0297	0.6533**
	G	0.7222	0.6108	0.7793	0.2818	0.5907
	E	0.3503*	0.4361**	0.4571**	0.2453*	0.6935**
3 6	P	0.7722**	0.6234**	0.5028**	0.5790**	0.8392**
	G	0.9249	0.7265	0.6351	0.9086	0.9466
	E	0.8345**	0.5753**	0.4380**	0.4390**	0.7792**
3 7	P	0.8687**	0.6678**	0.5627**	0.6176**	0.8480**
	G	0.9568	0.7540	0.7094	0.7997	0.8591
	E	0.7317**	0.6361**	0.5116**	0.5200**	0.8622**
3 8	P	0.7625**	0.6520**	0.5899**	0.6350**	0.7763**
	G	1.0469	0.8492	0.7607	0.7830	0.8480
	E	0.3546	0.8370**	0.5788**	0.8821**	0.7938**
4 5	P	0.6524**	0.3849**	0.5693**	0.2958**	0.6344**
	G	0.7586	0.5205	0.5925	0.0818	0.5745
	E	0.5614**	0.3477**	0.5517**	0.3871**	0.6647**
4 6	P	0.7353**	0.4817**	0.7260**	0.5543**	0.7966**
	G	0.8092	0.4424	0.9761	0.7925	0.8452
	E	0.6787**	0.4991**	0.5991**	0.5442**	0.7719**

(Continued overleaf)

Table 1 continued

Character combinations*		Correlation coefficients in cultivars from				
		Far-East	India	Middle-East	Africa	America
		1 s	2	3	4	5
4 7	P	0.8232**	0.4167**	0.7775**	0.4251**	0.7762**
	G	0.8806	0.2147	1.0424	0.3940	0.8483
	E	0.7917**	0.4842**	0.6774**	0.4643**	0.7522**
4 8	P	0.6254**	0.1842	0.6272**	0.3356**	0.6090**
	G	1.0216	0.1192	1.0130	0.1557	0.7124
	E	0.2126	0.2089*	0.5447**	0.3741**	0.5980**
5 6	P	0.4523**	0.5778**	0.4598**	0.3318**	0.6503**
	G	0.5824	0.8718	0.5159	0.0542	0.5633
	E	0.2978*	0.4051**	0.4441**	0.4808**	0.6945**
5 7	P	0.6373**	0.6888**	0.6095**	0.4403**	0.7884**
	G	0.6735	0.9088	0.6918	0.3512	0.8285
	E	0.6096**	0.5758**	0.6068**	0.4987**	0.7776**
5 8	P	0.4342**	0.5329**	0.6185**	0.3707**	0.5690**
	G	0.7077	0.7415	0.8073	0.1045	0.6593
	E	0.1203	0.4057**	0.6255**	0.5124**	0.5608**
6 7	P	0.8673**	0.7629**	0.8004**	0.7069**	0.8605**
	G	0.9613	0.7974	0.8768	0.9106	0.8843**
	E	0.7000**	0.7486**	0.7758**	0.6298**	0.8570**
6 8	P	0.7293**	0.5914**	0.7349**	0.7179**	0.7438**
	G	1.0115	0.8663	0.6337	0.9112	0.8804
	E	0.2805**	0.4675**	0.7774**	0.6564**	0.7278**
7 8	P	0.7899**	0.7272**	0.8399**	0.7497**	0.8320**
	G	1.0698	0.9777	0.9654	1.0490	0.7851
	E	0.3388**	0.6182**	0.8205**	0.6397**	0.8512**

* Characters 1 to 8 denote: 1. days to flower, 2. plant height, 3. main branch length, 4. number of primary branches, 5. stem girth, 6. number of leaves, 7. green weight and 8. dry weight.

* Significant at 5% level.
** Significant at 1% level.

genotypic correlations were positive between the stem girth and the dry weight and negative between the stem girth and the main branch length. The environmental correlations in all combinations between the main branch length, number of primary branches, stem girth, number of leaves, green weight and dry weight were significant and positive. The plant height was correlated significantly and positively at the environmental level with all other characters except the number of primary branches. Significant and positive environmental

correlations were also observed between the days to flower and the main branch length and dry weight.

E) *American material.* Significant and positive phenotypic and environmental correlations were observed in all possible combinations between the characters studied. The genotypic correlations between all character combinations except those involving height were mostly high and positive. High and positive genotypic correlations were also observed between the plant height and the days to flower, main branch length and dry weight.

The χ^2 test of heterogeneity of correlation coefficients indicated heterogeneity for 4 phenotypic and 16 environmental correlations over the five regions. The remaining correlation coefficients (24 phenotypic and 12 environmental) being homogeneous, their average correlation values were obtained and they were all significant (Table 2).

The heterogenous phenotypic correlation coefficients between (i) days to flower and number of primary branches (ii) main branch length and number of primary branches and (iii) main branch length and green weight were all significant and of similar magnitude among the Far-Eastern, Middle-Eastern and American materials and dissimilar between the African and Indian materials (Tables 1, 2). The correlation between the number of primary branches and stem girth was of comparable magnitude and significant between all the regions except Africa. While the first (i) correlation was insignificant and negative in the Indian, it was highly significant and positive in the African material (Table 1). The second (ii) correlation was insignificant and low and the third (iii) correlation was significant and comparatively low in the African and Indian materials as compared to those of the other regions (Table 1).

Out of the 28 phenotypic correlation coefficients worked out, the African material differed significantly in 17 and 11 cases and the Indian in 11 and 12 cases from the Far-Eastern and Middle-Eastern materials, respectively. The Far-Eastern and American materials differed significantly amongst themselves in two cases only.

At the environmental level, the associations of plant height with all other characters were homogeneous. The majority of the remaining character associations were heterogeneous, over the five regions. The environmental correlation coefficients of the American materials differed significantly from the Far-Eastern, Indian and African materials in 10, 18 and 15 cases, respectively. The Indian and African materials, however, differed only in one case (leaf number — dry weight) out of 28 possible character correlation coefficients studied.

2. *Factor analysis.* Centroid factor analysis, using the environmental correlation matrices, revealed that in the materials from all regions, only one common causative influence (factor) could be extracted, to explain the inter-correlations of the fodder yield components, since the coefficients in the residual matrices were too low to allow for the extraction of more factors (Table 3). In the absence of an established method for testing the significance of the factor loadings, we arbitrarily selected a level of 0.3 as the lowest limit of the important factor loadings (SOKAL—DALY 1961). The factor loadings on all characters were positive in each regional material. The factor loading on the days to flower was less than 0.3 in the Far-Eastern and Indian materials, while those on the remaining characters, in all regional materials, were more than 0.3. Furthermore, in all regional materials, the factor loadings on the main branch length, stem girth, number of leaves and green weight were more than 0.5.

Factor analysis, using the genotypic correlation matrices, however, revealed that two factors in the Middle-Eastern material and one factor in the remaining regional materials could be extracted (Table 4). In the Far-Eastern, Indian, African and American materials, the factor loadings on most of the characters were more than 0.7, and those were all positive.

In the Middle-Eastern material, factor 1 affected the plant height negatively and the remaining characters positively. The positive loadings on the different characters ranged from 0.7 to 1.0, the maximum being in the dry weight, followed by those on the number of primary branches and green weight. Factor 2 affected the number of primary branches and

Table 2

χ^2 values for the test of heterogeneity in 28 phenotypic (P) and environmental (E) correlation coefficients, average P and E correlation coefficients and significance of the difference between correlation coefficients in different inter-regional comparisons

Character combination		χ^2 value	Average correlation coefficients	Significance of the difference between regions for P and E correlation coefficients of different character combinations									
				AB	AC	AD	AE	BC	BD	BE	CD	CE	DE
1 2	P	4.2464	0.3627**					*	*				
	E	0.9640	0.2070										
1 3	P	8.3338	0.5080**										
	E	8.8306	0.3185**		×			×		×			
1 4	P	64.7416**	—	*	*	*		*	*	*	*		*
	E	9.7185*	—				×			×			×
1 5	P	3.7540	0.3004*			*			*		*		
	E	4.8390	0.1684*										
1 6	P	2.2953	0.4542**	*		*							
	E	18.2499**	—				×	×		×			×
1 7	P	2.6110	0.4621**	*		*							
	E	11.4882*	—							×			×
1 8	P	1.7090	0.2260**			*							
	E	8.3532	0.4219**		×		×	×			×		
2 3	P	5.9869	0.4930**		*			*	*				
	E	6.4715	0.4053**	×									
2 4	P	5.3392	0.1887*	*	*	*	*						
	E	6.8181	0.1595*										×
2 5	P	1.1298	0.3185**										
	E	8.8046	0.3452**							×			
2 6	P	4.7060	0.4219**		*	*	*	*			*	*	
	E	7.2594	0.3540**										
2 7	P	0.7611	0.4382**					*			*	*	
	E	7.2671	0.3452**							×			
2 8	P	3.0107	0.4777**		*			*			*	*	
	E	4.2209	0.3969**										
3 4	P	15.9266**	—	*		*		*		*	*	*	*
	E	27.7397**	—							×		×	×
3 5	P	19.5163**	—			*			*		*		*
	E	19.6105**	—				×			×		×	×
3 6	P	8.3162	0.6858**		*	*				*		*	*
	E	30.9765**	—	×	×	×				×		×	×
3 7	P	9.1098	0.7352**	*	*	*				*		*	*
	E	7.5648	0.6291**			×							×

Character combination		χ^2 value	Average correlation coefficients	Significance of the difference between regions for P and E correlation coefficients of different character combinations									
				AB	AC	AD	AE	BC	BD	BE	CD	CE	DE
3 8	P	3.3077	0.6963**	*	*	*						*	
	E	43.5350**	—	×		×	×	×			×	×	
4 5	P	4.5855	0.4382*	*		*		*			*		
	E	14.5394**	—	×						×			×
4 6	P	1.2573	0.6527**	*		*		*		*			*
	E	15.2434**	—							×			×
4 7	P	13.4887**	—	*		*		*		*	*		*
	E	17.1260**	—	×		×				×	×		×
4 8	P	8.4419	0.4400**	*		*		*		*	*		
	E	18.4421**	—				×	×		×			×
5 6	P	3.5643	0.5227**						*				
	E	24.1488**	—				×		×	×		×	×
5 7	P	6.2976	0.6584**						*			*	*
	E	118.4444**	—							×		×	×
5 8	P	1.7757	0.5080**								*		
	E	27.5856**	—		×	×	×	×					
6 7	P	2.4762	0.8110**			*							
	E	3.4146	0.7531**				×			×		×	
6 8	P	2.8934	0.6911**						*				*
	E	38.4356**	—		×	×		×	×	×			
7 8	P	1.8108	0.7857**					*					
	E	56.5380**	—	×	×	×	×	×		×	×		×

* Significant at 5% level.
** Significant at 1% level.
* Differences in phenotypic correlation coefficients significant between regions.
× Differences in environmental correlation coefficients significant between regions.
A, B, C, D, E denote Far-Eastern, Indian, Middle-Eastern, African and American materials, respectively.
Characters 1 to 8 as denoted in Table 1.

the dry weight negatively, but the remaining characters positively. The loadings of factor 2 were high (0.6) on the plant height and low (0.02 to 0.3) on the other characters. Different methods have been used for the estimation of the communalities (THURSTONE 1947). In this study, the estimated communalities were adequate for drawing the conclusions since the first two factors together accounted for 89.8% (factors 1 and 2 accounted for 79.2 and 10.6, respectively) of the total communalities in the genotypic correlation matrix. Factors 1 and 2 had a high negative association with each other (Table 4).

The object of this study was to assess and compare the nature and extent of correlations between the different components of fodder yield amongst 154 cowpea varieties belonging to five different geographical regions of the world. Attempts were also made (i) to compare the magnitude of such correlations between materials from different regions and (ii) to understand the causative influences (factors) responsible for the observed correlations between

Table 3

Centroid factor matrix of eight characters for environmental correlation matrix in cowpea cultivars from different regions

Characters*	Common factor coefficients in cultivars from				
	Far-East Factor 1	India Factor 1	Africa Factor 1	America Factor 1	Middle-East Factor 1
1	0.168	0.293	0.300	0.521	0.615
2	0.440	0.439	0.523	0.561	0.331
3	0.731	0.759	0.658	0.888	0.683
4	0.803	0.438	0.518	0.790	0.683
5	0.595	0.614	0.610	0.789	0.717
6	0.761	0.789	0.785	0.906	0.780
7	0.880	0.854	0.776	0.945	0.868
8	0.436	0.725	0.839	0.859	0.914

* Characters 1 to 8 as denoted in Table 1.

Table 4

Centroid factor matrix of eight characters for genotypic correlation matrix in cowpea cultivars from different regions

Characters*	Common factor coefficient in cultivars from						Communality	
	Far-East Factor 1	India Factor 2	Africa Factor 1	America Factor 1	Middle Factor 1	East Factor 2	Original	Calculated
1	0.977	0.867	0.969	0.889	0.739	0.337	1.000	0.661
2	0.932	0.862	0.714	0.362	0.162	0.661	0.384	0.464
3	1.005	0.879	0.819	0.933	0.776	0.251	0.779	0.665
4	0.960	0.289	0.634	0.777	0.995	0.141	1.000	1.010
5	0.730	0.861	0.124	0.710	0.801	0.023	0.807	0.642
6	0.955	0.932	0.997	0.895	0.806	0.298	0.976	0.739
7	0.979	0.945	1.009	0.906	0.992	0.020	1.000	0.984
8	1.005	0.961	0.915	0.999	1.030	0.129	1.000	1.079
Total contribution of factor					5.5	0.7		
% of total original communality					79.2	10.6		
Factor correlation						0.8759		

* Characters 1 to 8 as denoted in Table 1.

the characters studied. An understanding of these aspects, it was felt, would be helpful in a better planning and execution of a selection programme for improving the fodder production characters, since selection for one character is likely to result in progress for all positively correlated characters but in regression for all negatively correlated characters. This study revealed that, in a world germplasm collection of cowpea, the genotypic and phenotypic correlations between the various fodder production characters were significant and positive, barring a few character combinations in certain regional materials.

Inter-regional comparison of 28 phenotypic correlation coefficients, using Fisher's Z statistics, also revealed that 24 of them were homogeneous and their average correlation coefficients were significant. However, 4 other correlation coefficients were heterogeneous, indicating that perhaps a different type of genetic system was at work, in so far as these character correlations were concerned in the material from different regions. In fact KOHLI *et al.* (1971) have also observed differential variability of these characters when compared between the five regional materials. Most of the environmental correlation coefficients between the different characters, except the days to flower and plant height, reached the point of significance at $p = 5$ or 1 per cent, indicating that the environment also exerted a common influence on the expression of such characters. An inter-regional comparison of 28 environmental correlation coefficients revealed that 16 of them were heterogeneous, indicating a differential effect of the environment on characters involving such correlations. High environmental influence would limit the response to selection for specific characters since inter-environmental genetic slippage would be considerable between the different generations of evaluation and selection (DICKERSON 1955) at different locations and materials.

Since high genotypic and significant phenotypic positive correlations were mostly observed in all possible combinations between the main branch length, number of primary branches, stem girth, number of leaves, green weight and dry weight in all regional materials, we assume that such correlations were due to a common genetic background acting in the same direction on these characters. It may, however, be pointed out that caution should be observed in selection programmes using characters whose correlation coefficients (both phenotypic and environmental) showed heterogeneity among materials from different regions. The factor analysis, however, confirmed that only one common factor could explain the observed high correlations between these characters. The factor loadings, based on both genotypic and environmental correlation matrices, for these characters were also high in all regional materials. Thus, in order to make an improvement in the fodder yield in cowpea, emphasis should be laid on increasing the main branch length, number of primary branches, stem girth and number of leaves. In fact, the high estimates of heritability, accompanied by the high genetic advance of the quantitative traits, enable plant breeders to base their selection programme on the phenotypic performance of such characters (JOHNSON *et al.* 1955). KOHLI *et al.* (1971) reported reasonably high heritability and genetic advance (as a percentage of the mean) for the main branch length, number of leaves and green fodder weight in cowpea. This would suggest that more emphasis should be placed on the improvement of the main branch length and the number of leaves as compared to other characters, for improving the fodder yield in cowpea.

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*

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RESULTS AND PROBLEMS OF CHEMICAL WEED CONTROL FOR WHEAT IN HUNGARY

According to CRAMER (1967) 23.9% of the world production of wheat (85.5 million tons) is destroyed by various animal pests, diseases and weeds even today. Losses thus caused are 39.0% in Africa, 27.0% in Asia and South America, 24.0% in the Soviet Union and China and 19.7% in Europe. Of the losses 5% are caused by animal pests, 9.1% by diseases and 9.8% by weeds. The above pests are regular exploiters of wheat production in Hungary too. In Hungary the extent of losses mainly depends on the weather conditions. In years with favourable weather conditions or with a rather dry spring the damage does not exceed the European average. In rainy years, on the other hand, they are more serious, due mainly to fungal diseases, harvesting losses and an increased weed growth. In 1970 and 1975, for example, the national wheat yield average was lower by 5.8 and 5.5 q/ha, respectively, than in the previous year.

According to UJVÁROSI (1951) in 1947 32.5% of the wheat area was occupied by weed plants, and it was not a mere accident that the yield average was then only 8.4 q/ha. UBRIZSY (1968) — the pioneer of chemical weed control in Hungary — estimates the losses caused by weeds to be 15%. This percentage is still too high. The present paper is intended to contribute to the reduction of damage caused by weeds.

Meteorological data. A knowledge of the most important meteorological factors (temperature, precipitation) is a precondition for a better understanding of the wheat production results in Hungary and the experiences and problems of chemical weed control in wheat. We think it necessary, therefore, to present exact data on these factors (Tables 1, 2 and 3).

The temperature data presented fulfil the requirements of successful wheat growing. The amount of precipitation also satisfies the demands of efficient wheat production, though range is considerable. In the lowlands, for instance, the annual precipitation is about 500 mm, while on certain areas in the west of Hungary it may exceed 800 mm.

Table 1

Trends in temperature and precipitation averages (Budapest, 1901—1950)

	Months						
	I	II	III	IV	V	VI	VII
Temperature, °C	—0.8	1.1	6.2	11.4	16.8	19.9	21.9
Precipitation, mm	39	39	43	52	69	67	50

	Months					Annual average
	VIII	IX	X	XI	XII	
Temperature, °C	21.1	16.9	11.2	5.3	1.3	11
Precipitation, mm	48	45	54	61	50	617

Table 2

Temperature maxima and minima measured over 50 years (Budapest, 1901—1950)

	Months						
	I	II	III	IV	V	VI	VII
Maximum, °C	15.1	18.0	25.4	30.2	32.4	39.5	38.4
Minimum, °C	—21.7	—23.4	—13.6	—4.2	0.0	3.0	8.9

	Months					Annual max. and min.
	VIII	IX	X	XI	XII	
Maximum, °C	39.0	35.2	30.8	22.6	15.7	39.5
Minimum, °C	7.0	1.2	—9.5	—13.2	—19.1	—23.4

Table 3

Serial data on precipitation (1871—1950)

Months	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Keszthely (Transdanubia, Western Hungary)													
Average, mm	33	32	40	56	73	73	71	75	61	65	57	44	680
Maximum, mm	82	113	149	172	167	145	242	203	135	164	135	124	1098
Minimum, mm	0	0	2	4	11	9	11	10	1	7	6	2	390
Debrecen (Great Hungarian Plain, Eastern Hungary)													
Average, mm	31	29	36	45	62	72	64	59	45	56	51	41	591
Maximum, mm	105	81	100	146	127	170	246	156	145	138	142	117	874
Minimum, mm	2	0	3	6	7	20	5	6	3	5	0	2	342

Table 4

Wheat yield averages and NPK fertilizer active agent utilization in Hungary (1961—1975)

Year	NPK active agent, kg/ha	Crop area, ha	Yield average, q/ha
1961	—	989,018	19.3
1962	—	1,092,134	17.9
1963	—	969,191	15.6
1964	—	1,110,821	18.5
1965	75	1,082,000	21.7
1966	96	1,070,935	21.6
1967	112	1,159,135	25.9
1968	132	1,326,889	25.9
1969	153	1,319,625	27.1
1970	175	1,015,242	21.3
1971	201	1,270,358	30.7
1972	233	1,319,000	31.0
1973	250	1,294,038	34.8
1974	260	1,324,000	37.5
1975	270	1,300,000	32.0
1976	275	1,300,000	38,8

Bacsó (1966) uses the geographical situation of Hungary to explain this wide scattering. Hungary is under the influence of atmospheric currents coming at times from the continent (Soviet Union), at times from the Atlantic, and occasionally from the Mediterranean Sea. This is the cause of the variable nature of Hungary's climate and of the wide annual range.

For the reasons mentioned above the number of hours of sunshine also changes from year to year. Its values range from 1800 to 2000 hours a year.

Not only does the weather change from year to year, but the soils are also diversified in Hungary. There are chernozem-type soils highly suitable for wheat production; good and bad quality sands occupy a considerable area, and various types of forest soil, meadow clay, peat and even alkali soils are also found.

Trend of yield averages. The wheat yield averages are presented on the basis of data published by Koltay—Balla (1975). The yield averages of more than three-quarters of the past century (80 years) are not given in detail, because they did not show significant changes during this period. Nevertheless, smaller or larger fluctuations did occur as a response to weather. During the 80 years the yield averages of wheat were:

1870—1900	7.2—12.3 q/ha
1900—1925	9.6—13.7 q/ha
1925—1950	8.4—16.7 q/ha
1950—1960	11.8—17.0 q/ha

At the beginning of the sixties a decisive change occurred in wheat production. Since then, with some fluctuations, the yield averages have rapidly increased, as shown by the detailed data in Table 4.

The table reveals that compared to the yield averages between 1900 and 1950 the yield has more than doubled. On the basis of yield averages Hungary is now placed fifth in the world among countries with a wheat area of over 1 million hectares. This is mostly due to the following circumstances:

1. Production of varieties superior to the earlier ones (RAJKI 1959, 1960, 1964, LELLEY 1971).

2. Cultural practices better than those used previously (KEMENESY 1959, LÁNG 1965).

3. Mechanization of wheat growing (BURJÁN—KURUCZ 1966).

In addition to the above, the data of Table 4 also show the yield fluctuations. In this respect the yield decreases observed in 1970 and 1975 are worthy of special attention. An account of the causes has already been given: weeds are responsible for some of the losses. This question will therefore be thoroughly dealt with below.

Major weed plants of wheat in Hungary. After the end of World War II, UJVÁROSI (1951, 1966, 1973), UJVÁROSI *et al.* (1973a) made a national survey of weeds. From the results he established that at that time 297 weed species attacked the wheat stands, and 50 of them caused serious damage. The latter represented 85% of the total weed coverage. In order of importance the most frequent species were:

Convolvulus arvensis L., *Cirsium arvense* (L.) Scop., *Chenopodium album* L., *Stachys annua* L., *Centaurea cyanus* L., *Agropiron repens* (L.) P. B., *Consolida regalis* S. F. Gray, *Papaver rhoeas* L., *Sinapis arvensis* L., *Polygonum* spp., *Ambrosia elatior* L., *Anagallis arvensis* L., *Rubus caesius* L., *Matricaria* spp., *Apera spica-venti* (L.) P. B., *Lepidum draba* L., *Lathyrus tuberosus* L., *Sonchus arvensis* L., *Galium aparine* L., *Capsella bursa pastoris* (L.) Medic., *Cannabis sativa* L., *Alopecurus myosuroides* Huds., *Avena fatua* L., *Lamium* spp., etc.

As regards their distribution the weed species mentioned showed territorial heterogeneity.

According to the investigations made by UBRIZSY (1971), owing to changed cultural practices, and mainly because of the regular application of hormone-based herbicides, remarkable changes have occurred in the weed species, particularly since the sixties. The following species have been pushed into the background: *Agrostemma githago* L., *Papaver rhoeas* L., *Centaurea cyanus* L., *Sinapis arvensis* L., *Raphanus raphanistrum* L., etc. Weed species resistant to certain herbicides, on the other hand, are spreading and becoming more and more of a problem. Such species are: *Galium aparine* L., *Polygonum convolvulus* L., *Stellaria media* (L.) Cyr., *Veronica* spp., *Lamium* spp., *Apera spica-venti* (L.) P. B., *Alopecurus myosuroides* Huds., *Avena fatua* L., etc. Apart from Ubrizsy many other Hungarian authors (UJVÁROSI 1966, SZILÁGYI 1971, KÁDÁR 1971, KÜKEDI 1973, 1974, 1975a, 1975b) have also given an account of the changes that have taken place in the weed species. Detailed information on the subject can be obtained from foreign authors too (RADEMACHER 1962, 1963, 1968, 1970, HANF 1968, KURTH 1968, 1974, AMMON 1971, 1974, NAYLOR 1972, ARLT—FEYERABEND 1972, NEURUHRER 1961, 1975).

Possibilities of control. In Hungary crop rotation and plant tending operations were earlier used to protect the crops from weeds. However, with the increased ratio of cereal forecrops the strict rules of crop rotation have become increasingly difficult to observe. Traditional weeding operations cannot be carried out, partly due to the labour shortage and partly for economic reasons.

For this reason theoretical and practical experts carried out a search for chemical weed control methods suitable for the present conditions. In Hungary investigations of this nature were started by UBRIZSY (1957, 1962) immediately after World War II. However, in his opinion chemical weed control on a farm-scale only began in Hungary in 1954. Since favourable results were obtained, herbicides are being used on an ever increasing area. In 1970 87% of the wheat area of state farms was already treated with them (KACSÓ 1971).

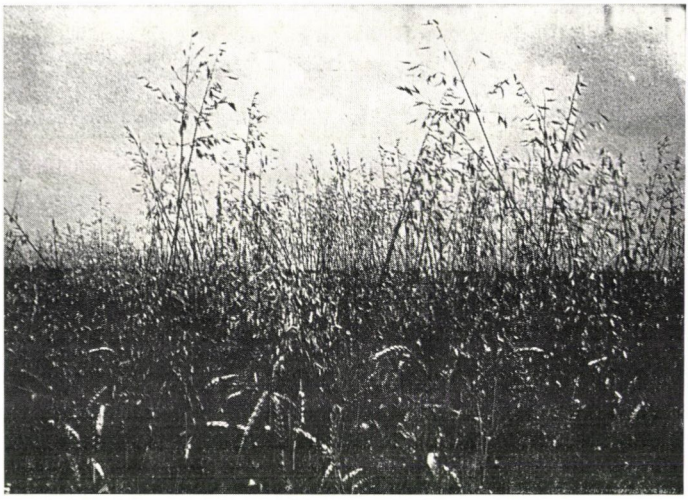

Fig. 1. Avena fatua L. in wheat

Fig. 2. Apera spica venti (L.) P. B. in wheat

In the same year on the co-operative farms this proportion was 60%. In 1975 herbicides were used for weed control over 1.1 million ha, 85% of the total wheat area of Hungary (ANONYMOUS 1975). Earlier the sodium salt of 2,4-D (Dikonirt) and Dikotex 40 containing MCPA as active agent were mostly used. For some years Sys 67 MA, a herbicide containing the same active agent (MCPA), has also been available. Against dicotyledonous, non-resistant weed plants these herbicides can be used efficiently. Dikotex 40 with MCPA as active agent is a particularly popular herbicide, since it is cheap, easy to handle, and its phytotoxic effect is low even under unfavourable weather conditions. Resistant dicotyledonous weed species,

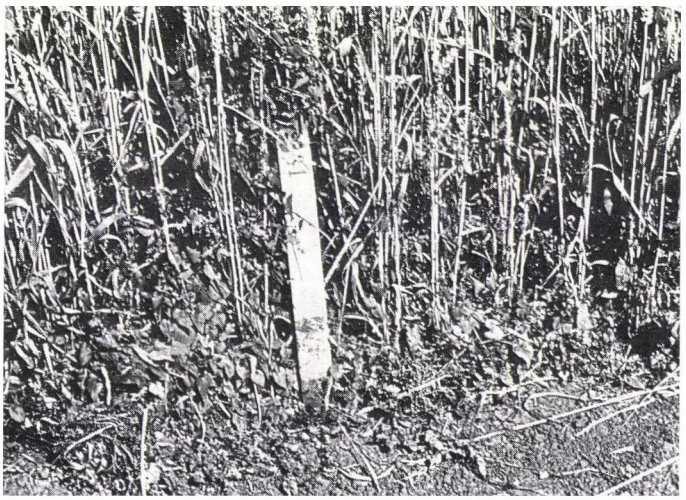

Fig. 3. Polygonum convolvulus L. in wheat

on the other hand, cannot be killed with the above herbicides. Therefore on areas infected by them Aniten-M containing flurenol + MCPA, Aniten-D containing flurenol + 2,4-D, Banvel M containing Dicamba + MCPA as active agents, and Gabonil, which is similar to the latter, are used. Keropur with MCPA + benazolin as active agent was successfully applied in experiments against certain resistant dicotyledonous weed species.

In connection with Banvel M, and particularly with Gabonil, it should be mentioned that in certain cases — depending on the weather — they are highly phytotoxic. The possible damage, however, can be substantially reduced if the time of spraying is correctly chosen and the instructions are strictly observed.

Matricaria chamomilla L., *Polygonum* spp. and many other resistant dicotyledonous weed species can be successfully controlled by using Faneron, which contains bromophenoxy active agent, and other members of the Faneron family. In our experiments a combination of Faneron + Dikotex 40, which has a wider range of action and is cheaper than Faneron, was efficiently used.

This herbicide combination has the advantage of destroying *Cirsium arvense* (L.) Scop. and *Lepidum draba* L. too, two weed plants frequently occurring in Hungary. In experiments carried out at Martonvásár satisfactory results were obtained with Brominal and Brominal plus, but these herbicides are not yet available in Hungary.

Of the resistant monocotyledonous weeds *Alopecurus myosuroides* Huds. and *Apera psica venti* (L.) P. B. are best controlled by Dicuran 80 containing chlortoluron as active agent. It has the advantage of acting on many dicotyledonous weed species as well.

Avena fatua L., a weed plant rapidly spreading in Hungary, can be eliminated by using Suffix and Bidisin forte (active agents: benzoylpropethyl and chlorphenprop-methyl, respectively).

Difficulties in chemical weed control for wheat

1. *Economic efficiency*. According to Ubrizsy (1962) and Gimesi (1969) a yield surplus of 2—3 q/ha can be expected from the herbicides under any circumstances. In the first fifteen years the chemical weed control of wheat did result in the expected yield surplus. However,

due to improved cultural practices — including regular herbicide application — on certain areas the weed coverage has been reduced. In such places not only can a yield increase not be expected, but even a yield decrease may occur, which makes the economic efficiency of herbicide application questionable. On the basis of chemical weed control experiments carried out at Martonvásár, KÜKEDI (1971, 1973, 1975a) reported a slight yield decrease as a response to herbicide application. In experiments carried out by HORNIG (1971), SCHUSTER—SCHREINER (1973) and GARBURG (1974) in the German Federal Republic the yield also decreased in certain cases. There is an increasing number of farms in Hungary, too, where in well developed, closed stands, without too many weeds, the herbicides do not give yield surpluses. It is therefore more and more difficult to decide upon the necessity of herbicide application.

2. *Phytotoxic effect.* As early as the fifties, BEREND—PODHRADSZKY (1950) and BEREND (1956) reported on the close relationship between the phytotoxic effect of herbicides and the weather. This relationship could also be demonstrated in weed killing experiments performed at Martonvásár. In our experiments Dikonirt, Dikotex 40, Faneron, Faneron multi, Keropur and Brominal plus caused no damage in 1974 when the spring was favourable, while in the rainy year of 1975 all except Dikotex 40 showed a phytotoxic effect and — in addition — reduced the yield. Similar observations were reported — partly before our experiments — by RADEMACHER (1962, 1963, 1970), MAAS (1968, 1970a, 1970b, 1972), MAAS—PESTEMER (1975) and HORNIG (1971).

3. *Varietal sensitivity.* On the basis of experiments conducted in the German Federal Republic BACHTHALER (1971) and KEES (1975) reported on differences in herbicide sensitivity between the varieties. No significant difference in herbicide sensitivity — either visible or shown in the yield — has been found so far between the varieties included in our experiments (Bezostaya 1, Avrora, Mv 2, Száva, etc.). On the other hand, the influence of weather is always felt under our conditions. It is possible that the new varieties will show differences in herbicide tolerance.

4. *Resistance.* Weed species resistant to certain herbicides have already been spoken of. Our experiences in this field agree perfectly with those obtained in countries north-west and west of Hungary, though these problems arose earlier there, due to earlier herbicide application. The rich experiences gained by the Western countries in this field can thus be well utilized and the resistant weeds successfully killed in Hungary.

5. *Damage caused by treading.* In the case of spraying in the field — especially in rainy weather — damage caused by treading cannot be avoided. Improvement in this respect is expected from the increasing number of aeroplanes and helicopters used in plant protection work.

Research tasks and practical work

According to NAGY—JERMY (1976) the tasks of research are: "Regular study of the transformation of the weed flora and early identification of new aggressive species. Examination of the appearance of herbicide resistant forms within the weed species.

Investigation into the autecology and physiology of the most important weed species with the view of developing new type herbicides and antidotes.

Examination of an inter- and intraspecific competition with a view to more rational herbicide application."

Agriculturalists also have their tasks. In the future — even more so than at present — changes in weed species must be taken into consideration and the routine application of herbicides avoided.

Nowadays, a basic requirement for herbicide application is to survey the weed species and weed number in each plot before spraying, because it is only on this basis that we can

decide whether herbicide application is necessary at all, and if so, which of the herbicides would be the most suitable.

For economic and other reasons chemical weed control in well developed, closed, weedless wheat stands should be considered more thoroughly than is now the custom. In perfectly weedless stands chemical weed control is unnecessary. Fields in need of herbicide treatment, on the other hand, should be sprayed at the optimum time with the greatest possible care.

Finally, what conclusions can be drawn from more than 20 years of chemical weed control on wheat in Hungary? According to the results and experiences obtained so far the herbicides have fulfilled our expectations. On weedy areas they have increased the yields and reduced both the weed growth and the losses of nutrient and water due to weed plants. Credit can also be given to herbicides for facilitating mechanical harvesting. With their help grain drying has become quicker because the crop contains less impurity. Again, such crops are easier to clean owing to the smaller number of weed seeds contained in them.

The results thus tip the balance in favour of herbicides, but the successful protection of crops from weeds is — and will always be — based on careful cultural practices, complemented by skilfully conducted chemical weed control.

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UTILIZATION OF DIETARY NITROGEN BY GROWING LAMBS

The proper evaluation of dietary protein is one of the most important problems in feeding animals. It is well known that the utilization of dietary protein is maximal at low levels of intake. When the intake of protein exceeds the requirement, the efficiency of utilization decreases rapidly.

Despite the fact that nitrogen balance trials may not provide accurate absolute estimates, it is generally agreed that they do provide relative measurements of the efficiency of nitrogen utilization.

Nitrogen metabolism in ruminants differs from that in non-ruminants (JUHÁSZ 1965). Utilization of protein in ruminants is determined largely by the ammonia formation in the rumen and by the concentration of urea in the blood. CHALMERS—SYNGE (1954) reported that the extent of ruminal ammonia formation is considered to be responsible for the differences found in the value of the protein. While blood urea is commonly considered to be a metabolic waste product of protein catabolism, PRESTON—PFANDER (1963) stated that blood urea nitrogen was directly proportional to the dietary protein level. Later in 1965, PRESTON *et al.* (1965) indicated that the protein status of the lamb can be at least partially assessed by the concentration of blood urea nitrogen.

The object of this experiment is to study the effect of different levels of dietary protein on nitrogen retention, ruminal ammonia and blood urea concentration in relation to the protein requirement of growing lambs.

Feeding of experimental animals. Twelve castrated Hungarian-Merino lambs were used in this experiment. At the beginning of the experiment the lambs were about 3 months old and weighed 20 kg. They were randomly divided into four groups, every group containing three animals. Four different levels of dietary protein in pelleted mixed rations (13.8, 16.5, 19.5 and 23.5 per cent) were fed to the first, second, third and fourth group, respectively. Cotton seed cake and linseed meal were used with corn and barley in different ratios to obtain the desired different protein levels. The mixed ration was supplemented with the vitamin and mineral mixture required for growing lambs. The chemical composition of the mixed

Table 1

Percentage of the chemical analysis of the mixed ration

	Dry matter	Crude protein	Ether extract	Crude fiber	Ash	Gross energy (kcal/g)
First group	90.92	13.84	5.00	3.44	4.26	4.42
Second group	90.88	16.48	5.54	5.28	4.50	4.64
Third group	90.86	19.50	6.23	5.50	5.20	4.71
Fourth group	90.60	23.50	6.35	6.15	5.70	4.80

ration is shown in Table 1. Concentrates with wheat straw were fed twice a day at a feeding level near *ad libitum*. The quantity of food mixture consumed was the same for every group. All animals had free access to water, salt licks during the whole experiment (143 days). They were healthy and their feces were examined for parasitic infection and were found free.

Nitrogen balance studies. Two animals from each group were penned in metabolic cages for the collection of excreta samples. Feces and urine were collected separately at 24 hr intervals for 8 successive days. Total introgen was determined by the Macro—Kjeldahl method.

Ammonia in the rumen. Rumen liquor was taken by a polythene stomach tube for ammonia nitrogen determination using Nessler-reagent as follows: 1 ml rumen liquor was deproteinized by 2 ml trichloroacetic acid. After centrifugation 0,5 ml of the supernatant was diluted with 4,5 ml distilled water, the dilution was dependent upon the ammonia concentration in the rumen liquor. 4 ml of Nessler-reagent were added to 1 ml of the diluted sample just before estimation directly in a Pulfrich-photometer using an S43 filter (JUHÁSZ—SZEGEDI 1965).

Urea in the blood plasma. Blood samples from the jugular vein were also taken parallel with the rumen samples. Urea was determined in the blood plasma using the diacetyl-monoxime (DAMO) method according to JUHÁSZ—SZEGEDI (1965) as follows: 0.1 ml blood plasma, diluted with 1.5 ml distilled water was added to 1.4 ml 10 per cent trichloroacetic acid. After centrifugation 1 ml of the deproteinized solution was added to 1 ml DAMO solution (1 per cent in 5 ml acetic acid) plus 4 ml acid mixture (60 ml H_2SO_4 + 240 ml H_2O + 22 ml perchloric acid). It was heated in a water bath strongly boiling for 25 minutes in stoppered test tubes. Readings of extinction were taken in a Pulfrich-photometer using an S47 filter.

The rumen and blood samples were taken three times through the whole experiment at intervals of 45, 86 and 143 days. Each time the samples were collected before feeding; 3 and 6 hr after feeding.

Statistical analyses were carried out according to SNEDECOR (1953).

Nitrogen balance. As shown in Table 2 the nitrogen retention (g/day) increased with increasing nitrogen intake. At the same time the nitrogen retention; i.e. percentage of intake, did not increase, but even decreased with increasing nitrogen intake.

Although the digestible nitrogen intake (DNI) was higher in the second, third and fourth groups than in the first one, the mentioned DNI for the first group was found to be adequate for growing lambs. MAHMOUD (1972) did not find any significant increase in live body weight by increasing the protein level up to 13.8 per cent in the lambs' rations. These results agree fairly well with those obtained by SCHELLING *et al.* (1967). They showed no

Table 2

Feed intake, nitrogen retention and digestibility for the different groups

Group and No. of animal	First			Second		
	25	28	average	38	115	average
Dry matter intake (g/day)	1192	1189	1191	1217	1188	1203
Dry matter digestibility %	75.2	72.2	73.7	66.8	70.7	68.8
N intake (g/day)	25.43	25.33	25.41	32.03	31.56	31.79
Urinary N (g/day)	3.08	5.10	4.09	6.70	5.14	5.92
Fecal N (g/day)	6.54	6.90	6.72	8.62	8.36	8.49
N retention (g/day)	15.81	13.39	14.60	16.71	18.06	17.39
N retention (% of intake)	62.1	52.7	57.4	52.1	57.2	54.7
Digestible N intake (g/day)	18.87	18.48	18.68	23.38	23.19	23.29
Initial live weight (kg)*	31.5	36.5		37.2	31.5	
Final live weight (kg)*	32.5	37.5		38.5	38.5	

Group and No. of animal	Third			Fourth		
	58	59	average	85	91	average
Dry matter intake (g/day)	1220	1210	1215	1164	1158	1161
Dry matter digestibility %	66.6	67.2	66.9	65.9	65.4	65.7
N intake (g/day)	36.79	36.62	36.71	42.36	42.36	42.36
Urinary N (g/day)	7.82	7.88	7.85	9.74	11.58	10.66
Fecal N (g/day)	9.72	9.62	9.67	10.49	9.73	10.11
N retention (g/day)	19.25	19.12	19.19	22.13	20.96	21.55
N retention (% of intake)	52.3	52.2	52.3	52.2	49.4	50.8
Digestible N intake (g/day)	27.04	26.99	27.02	31.85	32.57	32.21
Initial live weight (kg)*	29.8	33.5		30.5	30.8	
Final live weight (kg)*	31.5	34.5		31.5	31.5	

* Weight of animals before and after 8 days collection period.

significant differences in the average daily gain of lambs fed four dietary protein levels (13.5, 16.2, 18.9 and 21.6 per cent).

A significant positive correlation was found between DNI and urinary nitrogen ($r = 0.966$, $P < 0.01$). The regression line is illustrated in Fig. 1. Moreover it could be noticed from Table 2 that the fecal nitrogen also increased with increasing the level of dietary protein.

As shown in Table 2, it was interesting to note that the dry matter digestibility decreased from 73.7 to 65.7 per cent with increasing nitrogen intake from 25.41 to 42.36 g/day. SMITH *et al.* (1960) reported that when the total nitrogen content of the ration of lambs increased

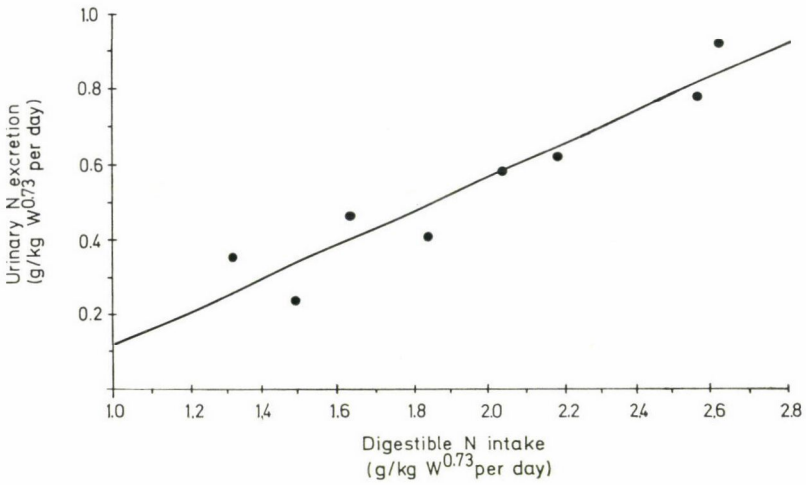

Fig. 1. Relationship between urinary nitrogen excretion (y) and digestible nitrogen intake (x)
($y = 0.448x - 0.326$)
$kgW^{0.73}$ = metabolic live weight (86 days feeding)

from 1.5 to 2.0 per cent it did not affect the retention of absorbed nitrogen, but significantly decreased the digestibility of organic matter and crude fiber.

Ruminal ammonia and blood urea concentration. As shown in Table 3, the ammonia-N concentration in rumen liquor was generally increased by increasing the level of protein in the ration. This is in accordance with the results of MOIR—HARRIS (1962) and ELLIOT—TOOPS (1964). The latter investigators stated that high apparent requirements of digestible nitrogen were associated with relatively high ruminal ammonia levels, but the latter were not considered to be the cause of high requirements. MOIR—HARRIS (1962) found that the level of ammonia accumulation in the rumen decreased consistently as the food nitrogen was reduced. They added that at the lowest levels of intake 2.5 m/day, there was frequently no measurable ammonia present in the rumen.

Table 3

Mean[a] concentration of ammonia-N (mg/100 ml) in rumen liquor for different groups

	First group	Second group	Third group	Fourth group
45 days feeding	18.1 ± 2.32[b]	10.5 ± 0.01	27.7 ± 5.39	68.2 ± 12.98
86 days feeding	19.8 ± 3.77	22.0 ± 3.20	24.3 ± 2.20	37.7 ± 2.07
143 days feeding	— —	26.4 ± 9.12	33.6 ± 8.32	42.4 ± 2.61

[a] Mean of three animals, average of two determinations 3 and 6 hours after feeding for each animal.
[b] Standard error.

Table 4

Mean[a] concentration of urea in blood plasma (mg/100 ml) for different groups

	First group	Second group	Third group	Fourth group
45 days feeding	41.4 ± 1.27[b]	41.2 ± 3.22	63.2 ± 4.34	80.1 ± 4.35
86 days feeding	45.1 ± 6.11	60.9 ± 6.88	74.7 ± 3.39	88.7 ± 6.41
143 days feeding	— —	46.8 ± 2.52	59.2 ± 3.05	67.4 ± 4.10

[a] Mean of three animals, average of two determinations 3 and 6 hours after feeding for each animal.

[b] Standard error.

Table 5

Analysis of variance of ammonia-N in rumen liquor and urea in blood plasma as affected by different groups

	Source of variation	DF	Mean square	
			Ammonia-N	Urea
45 days feeding	Groups	3	878.99**	396.91**
	Error	8	93.76	14.20
	Total	11		
86 days feeding	Groups	3	80.40	14.28**
	Error	8	11.96	1.46
	Total	11		
143 days feeding	Groups	2	82.72	111.27*
	Error	6	62.64	11.94
	Total	8		

* $P < 0.05$
** $P < 0.01$

After 45 and 86 days feeding, significant differences were found in the ruminal ammonia-N concentration for the different groups. However, after 143 days feeding, the differences were not statistically significant (Table 5).

After 45 days feeding very high ruminal ammonia-N concentration was found in the fourth group (68.2 mg/100 ml) as compared with the first group (18.1 mg/100 ml). There was a possibility of a slight toxic reaction due to the high level of ammonia in the rumen in the fourth group which may have resulted in the poor utilization of nitrogen.

By increasing the protein level in the ration, the urea concentration in the blood plasma was increased (Table 4). As shown in Table 5, significant differences were found in the blood plasma as affected by the different levels of dietary protein.

A significant positive correlation was found after 45 days feeding between nitrogen intake (NI) and urea in the blood plasma ($P < 0.05$; $r = 0.966$). After 86 days feeding a

highly significant correlation was obtained ($P < 0.01$; $r = 0.999$). Although ammonia-N in the rumen increased by increasing NI, the correlation between them was found to be non-significant. These results mean that blood urea is a more accurate indicator of the NI level than the ruminal ammonia-N concentration. LEWIS (1957), reported that changes in the diet lead to different levels of blood urea concentration which can be correlated with the different ruminal ammonia concentrations. His results also showed that under a given feeding regime the concentration of blood urea in the sheep was constant and directly related to protein intake. JUHÁSZ (1965) found that in ruminants the amount of accumulated ammonia present in the rumen liquor was dependent on the actual level of blood urea.

A close relationship, using growing finishing lambs, was found by PRESTON *et al.* (1965) between blood urea nitrogen and NI. They stated that blood urea nitrogen in excess of 10 mg/100 ml would indicate adequate protein intake with the type of ration fed in their experiments. In the present study this value was 21 mg/100 ml. However, LEIBHOLZ—COOK (1967) observed a decrease in the concentration of urea in the blood plasma of lambs starved for 1—3 weaks when compared with the control fed animals.

As mentioned previously, the live body gain did not increase by increasing the dietary protein up to 13.8 per cent in the lambs ration. MCDONALD (1969) reported that when the diet had a higher protein content and the nitrogen was available to the animal in excess of its requirement the excess of nitrogen was converted mainly to urea and the blood urea nitrogen was high. This explains why the cycle of urea nitrogen in the third and fourth groups confers no benefit for the animal.

The results of this study could be confirmed by the work of SOMERS (1961) who found that the difference in urea metabolism at high and low nitrogen intakes was well shown by the injection of urea into the blood stream. At high nitrogen intake, the urea is promptly excreted in the urine, but at low nitrogen intake, nitrogen is retained in the body and a negative nitrogen balance may be converted to a positive nitrogen balance.

A large amount of nitrogen retention (more than 14 g N per day) was found in the nitrogen balance experiments compared with the daily weight gain. As shown in Table 2, the live weight of the animals did not increase by increasing the nitrogen retention. The losses of nitrogen during balance trials were investigated by several workers. The results obtained by NEHRING (1957), MULLER *et al.* (1960) and COSTA (1960) were reviewed by DUNCAN (1966). Cumulative nitrogen balances obtained suggested higher retentions of nitrogen than were revealed by carcass analysis. There was no loss of nitrogen on the lower protein intake, but on the higher there was a systematic loss. The magnitude of the positive balance was directly related to the nitrogen intake. False positive balance of nitrogen occurs only when the nitrogen intake is in excess of the requirement.

As shown in the present work, by lower levels of nitrogen intake more reliable results for nitrogen balance, as an indication of live weight gain, were obtained. So the live weight gain was not completely responsed by the nitrogen retention.

The endogenous nitrogen circulation was higher in those groups which received higher levels of dietary protein; i.e. the accumulation of a large amount of ammonia in the rumen and a high concentration of urea in the blood plasma. A substantial amount of retained nitrogen is also required for wool production. Moreover, as explained by BAINTNER (1972), in special organs of the animals, a part of the nitrogen in the form of non-protein-nitrogen is also found. However, BRENT *et al.* (1961) stated that the wide variability of the per cent nitrogen retained between individual lambs of any given ration indicated that nitrogen retention may not be an accurate measurement for the evaluation of the rations.

It is concluded that the nitrogen balance combined with the determination of ammonia in the rumen and urea in the blood plasma is quite a good indicator for the evaluation of dietary protein for growing lambs (JUHÁSZ 1965).

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ALKALOID SPECTRUM OF SEEDLINGS AND REPRODUCTIVE ORGANS IN SOME POPPY (PAPAVER SOMNIFERUM L.) VARIETIES

Poppy breeding work has been carried on in our department for the last 28 years, always keeping in mind the interests of the Hungarian pharmaceutical industry and public food supply. With the collaboration of a number of research workers four improved poppy varieties were produced during this period. Two of them, SB-morphine poppy (SÁRKÁNY—DÁNOS 1957, SÁRKÁNY *et al.* 1959) and BC-2 hybrid poppy, were included in commercial production in 1960 and 1970, respectively, after they had been given state certification (SÁRKÁNY—SÁRKÁNY-KISS—VERZÁR-PETRI 1966, SÁRKÁNY—DÁNOS—SÁRKÁNY-KISS 1971).

Our poppy breeding trials have since been completed with phenological, morphological, cyto-histological and phytochemical analyses. In the course of our investigations we studied the relation between alkaloid formation and tissue structure, on the one hand in seeds and seedlings (SÁRKÁNY *et al.* 1966, SÁRKÁNY—MICHELS-NYOMÁRKAY—VERZÁR-PETRI 1967, SÁRKÁNY—MICHELS-NYOMÁRKAY—VERZÁR-PETRI 1970, SÁRKÁNY—MICHELS-NYOMÁRKAY—GRACZA 1972, M. NYOMÁRKAY 1965, 1970a, 1970b), on the other in reproductive shoots, that is, in flowers and buds (SÁRKÁNY—M. NYOMÁRKAY—GRACZA 1974). We have arrived at the conclusion that in meristem tissues alkaloids can be demonstrated in spite of the absence of primordial laticiferous vessels. So we theoretically agree with ILYIN (1966) and FAIRBAIN—PATTERSON (1966), who regarded the alkaloids as sources of energy at that stage of development.

This opinion was confirmed by the high alkaloid content of anthers found in the flowers during our investigations (SÁRKÁNY—NYOMÁRKAY—GRACZA 1974).

Keeping in view the results obtained so far we started further investigations and studied 13 or 14 varieties from our poppy variety collection, grown at the Biological Station of the University at Göd. We compared the alkaloid spectrum data obtained for the vegetative organs of 3, 5 and 7 day old seedlings kept in Petri dishes at room temperature under illuminated conditions, and those for the reproductive organs — i.e. petals, androecium and gynoecium of opening flowers —, mature capsules and seeds. The names of the varieties are given in the tables attached.

This evaluation was designed to establish whether these correlations and chemotaxonomic (genetic) characteristics, relations and possible quantitative or qualitative differences could be demonstrated within and between the examined varieties.

Experimental material of different ages and nature was collected regularly between 9 and 11 a.m., then divided into its component parts and, after 10 minutes of enzyme inhibition at 105°C, dried at room temperature. After the usual method of extraction and purification — according to PFEIFER (1956) — chromatography was carried out on a neutral layer using the method of NEUBAUER—MOTHES (1961). The spots were developed with Dragendorff's reagent and compared by standard series. The analyses were generally performed with 3—4 or sometimes even more replications, and the spots were measured by planimetry.

The examinations covered the following alkaloids: narceine, morphine, codeine, thebaine, papaverine, narcotine; — protopine, laudanine, laudanozine. In the case of seedlings the data generally refer to 50 plants. In the analysis of flower parts three flowers, one on each occasion, were used, and the mean values are included in the figures.

The results obtained so far for the seedlings and flower parts may be summarized as follows. Concerning the alkaloid spectrum of shoot and root in 3, 5 and 7 day old seedlings (Fig. 1), it was found that the total alkaloid content of the young shoot at the first two stages of development was mostly lower than, or equal to that of the root. At the third stage of development it was usually the other way round. When comparing the joint values of shoot and root, that is, the total alkaloid content of the whole seedling, we can see that the varieties

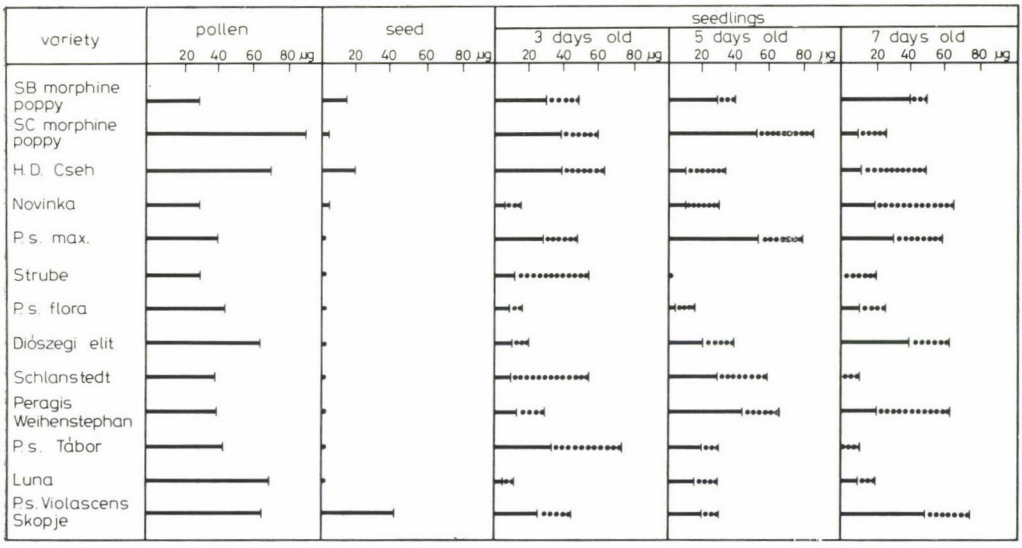

Fig. 1. Total alkaloid content in some varieties of the poppy variety collection, Alsógöd, 1971—72 (——— root, ... hypocotyl + cotyledon)

excellent at all three stages of development — i.e. containing 60—85 µg alkaloids — are: P.s.Tábor (75 µg), P.s.max (80 µg) and Peragis W.-st. (65 µg) at 5 days old, and P.s.Violascens (75 µg), Novinka (65 µg), Diószegi elit (65 µg) and Peragis Weihenstephan (65 µg) at 7 days old. On the other hand, there are varieties with medium and low values, e.g. Luna and P.s. Flora (5—10 µg) at 3 days old, Strube (0.5 µg) and P.s.Flora (15 µg) at 5 days old, and P.s. Tábor (10 µg), Schlanstedt (10 µg), Strube (20 µg) and Luna (20 µg) at 7 days old.

All this suggests that the alkaloid spectrum and the total alkaloid content in the young shoots and roots of different age seedlings are not sufficiently specific of the variety, and fluctuate so much that these results cannot by themselves be used in the breeding work to predict the tendency towards higher alkaloid productivity. We therefore extended the investigations to include the reproductive organs, more exactly, the flower. Data on the total alkaloid content and alkaloid spectrum of samples taken from certain parts (sepal, petal, filament, pollen-filled anther, mature pollen grains, pistil, flower stem) of opening flowers or 13 poppy varieties selected from the variety collection (Figs 2—8) also raise some interesting questions requiring further investigations.

Namely, according to the results of analyses no alkaloid could be pointed out in the sepals of 9, petals of 13, filaments of 3, pistils of 4 and flower stems of 5 varieties. It was extremely remarkable, on the other hand, that in all 13 varieties the pollen-filled anthers, and more particularly the mature pollen grains, and in 10 varieties even the filaments, contained fairly noteworthy amounts of total alkaloids, e.g. in SC the anther contained 40 µg, the mature pollen 90 µg and the filament 40 µg. The corresponding figures were 60 : 70 : 40 for H.D., 55 : 70 for Luna and 65 µg for P.s.Violascens. As for the alkaloid spectrum of flower parts, we found that in certain varieties narceine, thebaine and morphine were the most frequent alkaloids, while laudanine and papaverine hardly occurred, if at all. Laudanozine was not demonstrated in any of the varieties during the investigations. The range of alkaloids is also very different in the varieties. Seven of the nine alkaloids examined were demonstrated

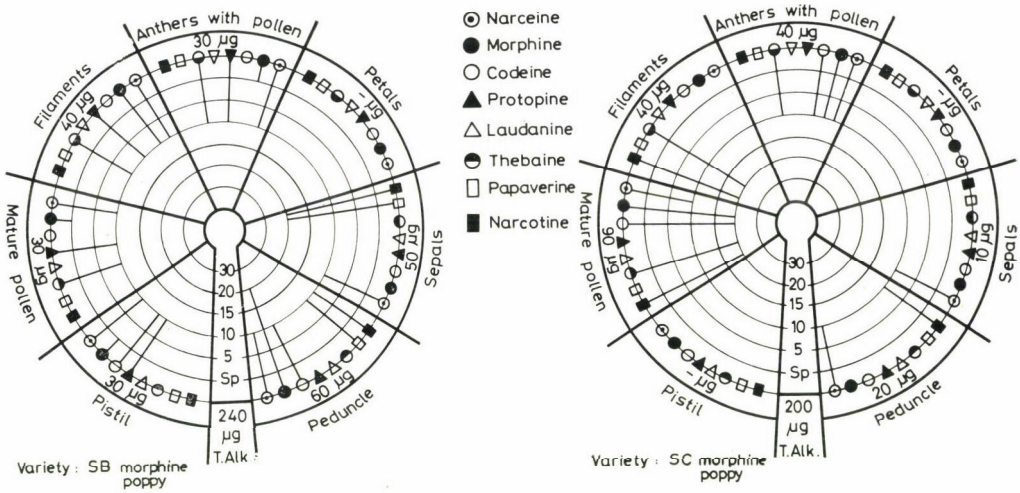

Fig. 2. Alkaloid spectrum and total alkaloid content in the flower organs of some poppy varieties, in µg/cg dry matter, Alsógöd, 1971

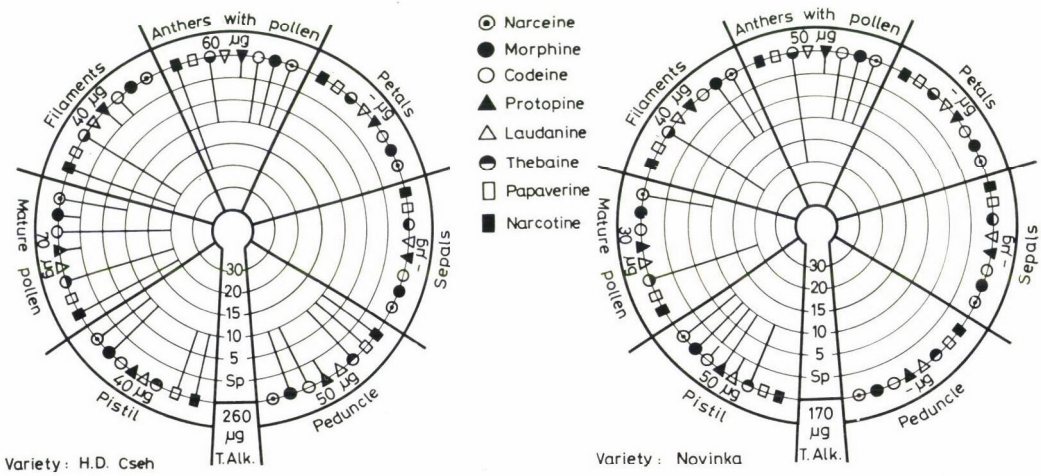

Fig. 3. Alkaloid spectrum and total alkaloid content in the flower organs of some poppy varieties, in µg/cg dry matter, Alsógöd, 1971

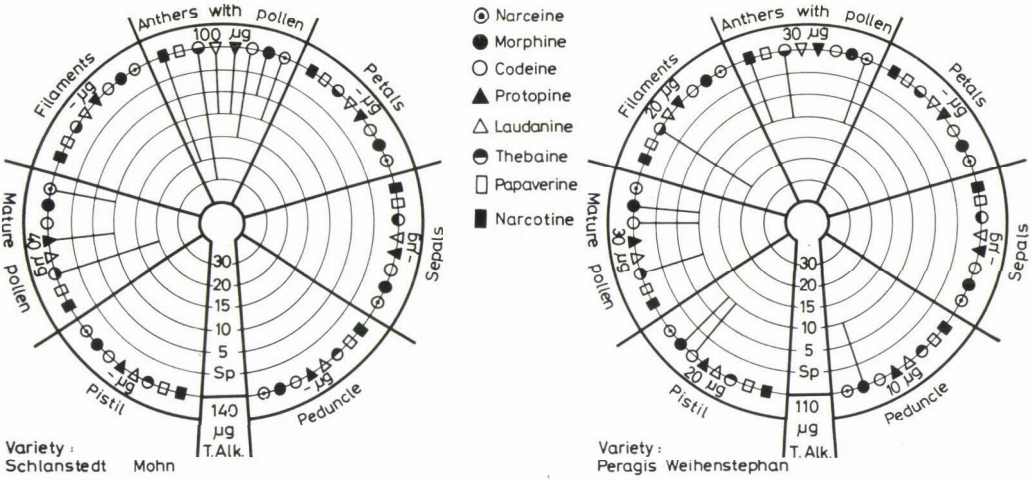

Fig. 4. Alkaloid spectrum and total alkaloid content in the flower organs of some poppy varieties, in µg/cg dry matter, Alsógöd, 1971

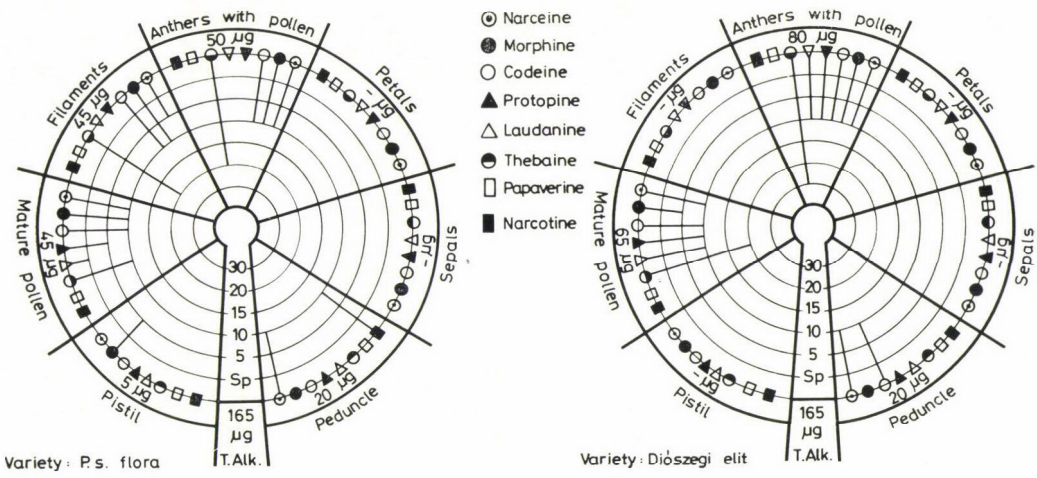

Fig. 5. Alkaloid spectrum and total alkaloid content in the flower organs of some poppy varieties, in µg/cg dry matter, Alsógöd, 1971

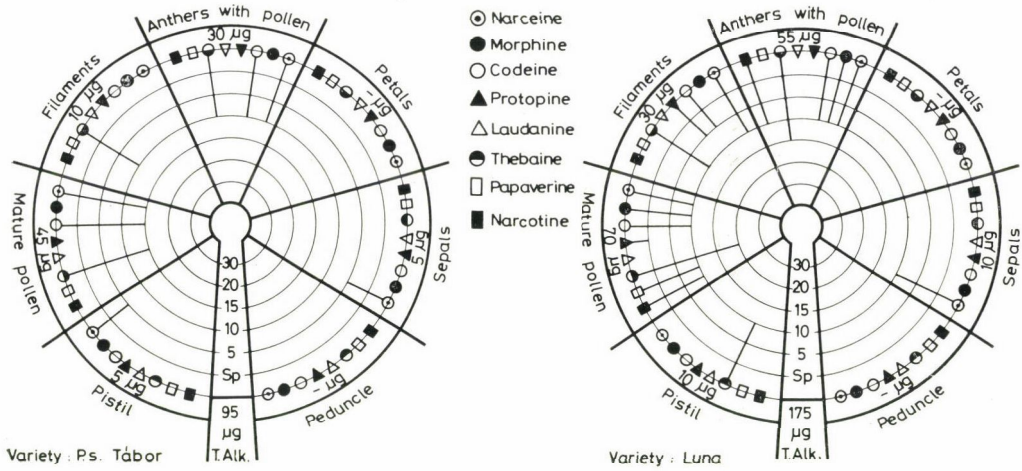

Fig. 6. Alkaloid spectrum and total alkaloid content in the flower organs of some poppy varieties, in µg/cg dry matter, Alsógöd, 1971

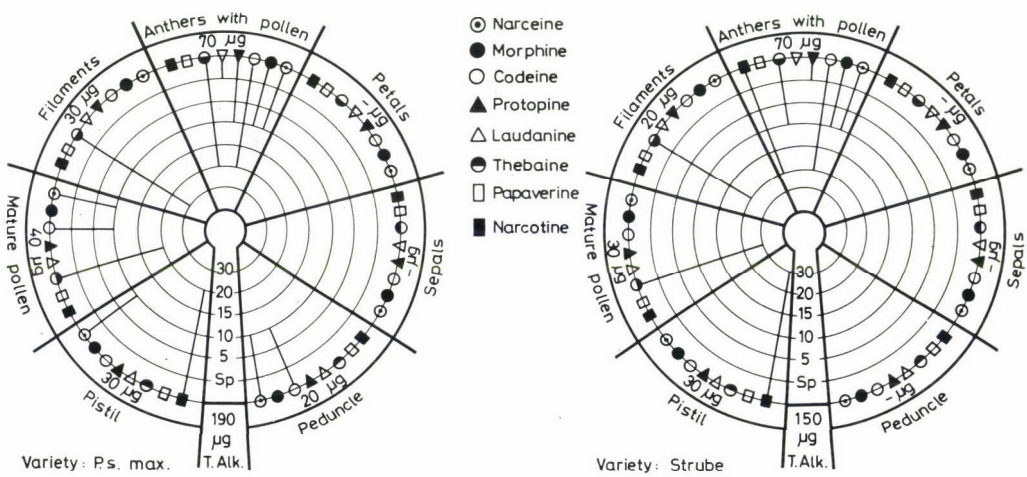

Fig. 7. Alkaloid spectrum and total alkaloid content in the flower organs of some poppy varieties, in µg/cg dry matter, Alsógöd, 1971

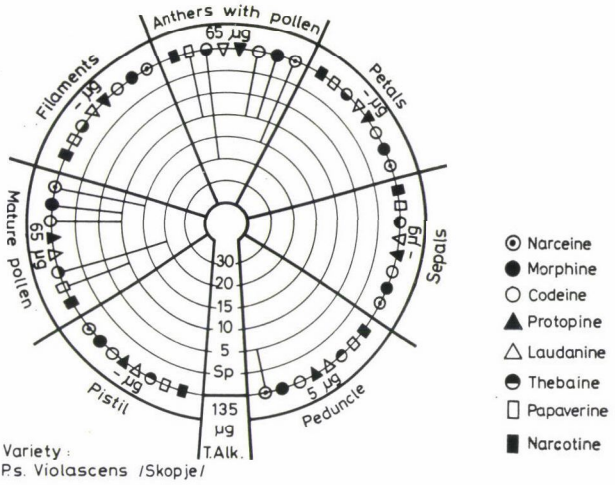

Fig. 8. Alkaloid spectrum and total alkaloid content in the flower organs of some poppy varieties, in µg/cg dry matter, Alsógöd, 1971

Table 1

Alkaloid spectrum of pollen in some poppy varieties of the variety collection

Variety name	Alkaloids (µg/cg dry matter)								
	Narceine	Morphine	Codeine	Protopine	Laudanine	Thebaine	Papaverine	Narcotine	Total alk.
SB morphine p.	10	tr.	—	10	—	10	—	—	30
SC morphine p.	10	20	20	—	—	20	—	20	90
H. D. Cseh	10	tr.	20	tr.	—	20	—	20	70
Novinka	10	—	—	—	—	20	—	—	30
P. s. max.	10	—	10	—	—	20	—	—	40
Strube	—	—	—	—	—	30	—	—	30
Ankara	10	—	—	10	tr.	20	—	—	40
P. s. flora	10	10	10	5	tr.	10	—	—	45
Diószegi elit	10	5	10	10	10	20	—	—	65
Schlanstedt	10	—	—	10	—	20	—	—	40
Peragis Weihenstephan	10	10	10	—	—	10	—	—	40
P. s. Tábor	15	—	15	—	—	15	—	—	45
Luna	10	10	10	tr.	—	20	10	10	70
P. s. Violascens Skopje	15	10	10	—	—	20	10	—	65

Table 2

Alkaloid spectrum of capsule in some poppy varieties of the variety collection

Variety	Alkaloids (‰)					
	Morphine	Codeine	Thebaine	Papaverine	Narkotine	Total alkaloids
SB morphine p.	4.0	0.2	0.5	0.4	—	5.1
SC morphine p.	5.0	0.6	0.8	2.0	0.4	8.8
H. D. Cseh	6.0	0.5	1.5	2.0	0.4	10.4
Novinka	6.0	0.4	0.8	0.2	0.4	7.8
P. s. max	5.0	0.5	0.6	0.2	0.3	6.6
Strube	8.0	0.4	0.5	0.2	tr.	9.1
P. s. Flora	6.5	0.4	0.6	0.2	0.3	8.0
Diószegi elit	4.0	0.5	0.5	0.2	0.7	5.9
Schlanstedt	4.0	0.3	0.4	0.2	0.4	5.3
Paragis Weihenstephan	5.5	0.5	0.7	tr.	0.1	6.8
P. s. Tábor	4.5	0.4	0.4	0.2	0.4	5.9
Luna	3.5	0.6	0.4	0.3	0.6	5.4
P. s. Violascens	4.0	0.5	0.4	1.0	1.2	7.1

in six varieties: SB, HD Cseh, P.s.Flora, Schlanstedt, Luna and P.s.max; while in the variety P.s. Tábor only three alkaloids (narceine, codeine and thebaine) were found. The rest of the poppy varieties studied fall between these two extremes. Furthermore, it is remarkable that in most varieties the pollen-filled anther and the pollen grains have the richest alkaloid spectrum (Figs 2—8 and Table 1). The figures show that the pollen contains thebaine in all the 13 varieties examined, together with some other alkaloids, depending on the variety. Both the number of the different kinds of alkaloid and the total alkaloid content were highest in the mature pollen grains of the varieties SC, H.D. Cseh, Diószegi elit, Luna and P.s. Violascens.

When comparing the alkaloid spectrum of mature capsules with that of the above pollen samples we find that the alkaloid content is similarly high in the dry capsules of SC, H.D. Cseh and P.s. Violascens. In the case of the other varieties greater or lesser differences and shifts of proportion are found (Table 2). According to the results of our analyses no correlation can be found between the alkaloid contents of seedlings and flower parts within a variety. Attention should be paid, however, to the alkaloid spectrum of pollen samples containing no latex, the origin of which is not satisfactorily explained; it may be connected with the intensive meristematic activity (microsporogenesis) taking place in the anthers.

The interspecific differences in the alkaloid spectrum of the pollen grains could perhaps be characteristic of the varieties.

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VARIABILITY AND HERITABILITY STUDIES ON THE MAJOR AGRONOMIC CHARACTERS OF CAPSICUM FRUTESCENS GROWN IN EGYPT

Variability studies seem to be essential, as genetic improvement is based mostly on heterogeneous genetic materials. There is an increasing interest in variation as an effective tool for modern plant breeders. Despite the fact that the literature is full of studies of variation itself and its application to crop plants, very little work has been carried out on variation in the genus *Capsicum*, particularly in the field of plant breeding and releasing new varieties. In spite of the huge number of published reports on the physiology and cultural practices of the medicinal plants, there is no comprehensive study on the varietal breeding of such crops. The improvement by plant breeders of the hereditary economic characters of these plants has been very limited.

Capsicum is used as a medicinal plant for its pungent alkaloid "capsaicin", which is found mainly in the inner walls of *Capsicum* fruits. Any improvement in the yield of capsaicin must include, besides the capsaicin percentage, other economic characters which are components of the total yield of the plant. In a previous work (AL-HAMIDI *et al.* 1975; in press), variation in the capsaicin content was studied. The present work is aimed at contributing on the range of variation in the major agronomic characters in *Capsicum frutescens*. Interest was also given to estimating the heritability values of the studied traits. Such study may offer some essential foundations for future genetic studies on the genus *Capsicum*. This investigation seems to be very important for any suggested improvement in *Capsicum* and for the releasing of highly pungent varieties.

Bulked "Shatta" seeds of *Capsicum frutescens*, which represents the genus *Capsicum* marketed in Egypt, were sown in the first year. The following traits were determined on an individual plant basis: 1. Weight of ten green fruits: When the fruits reached their maximum volume, ten fruits were harvested at random and weighed. This maximum volume was always found to occur when the fruits were yellowish-green in colour. 2. Weight of ten red fruits: At full maturity, ten fruits with dark red colour were harvested at random and weighed. 3. Volume of ten red fruits: The volume of ten red mature fruits was measured in cubic centimetres by water displacement in a graduated cylinder. 4. Number of main branches on the plant: At the end of the growing season and before digging out the plants, the number of main branches on the first node was recorded.

Self-pollination was carried out on each surviving plant individually. A random sample of the parental plants was taken to initiate the families grown in the second year. The determinations made on the parental plants were repeated in the same manner on each member of the progeny families.

Biometrical constants such as the range, mean, standard deviation, standard error and coefficient of variation were estimated from the parents as well as from the family means. To represent the individual parental plants in the form of frequency distribution curves, the data were transformed to the logarithmic scale so that the distribution approached the normal.

The range, standard deviation, standard error, coefficient of variation, frequency distribution curves and the figures revealed that extremely large variability existed in all the characters studied.

Table 1 shows the statistical determinations for the characters studied, while figures 1—4 illustrate the frequency distribution curves of the traits. Figures 5—10 show different types of fruits collected from the parental plants.

The range in weight of ten green fruits was from 2.1 to 30.0 g with a mean value of 7.2 g and a mode of 3.05 g. The standard deviation and coefficient of variation were 6.44 and 89.44% respectively. The weight of ten red fruits ranged from 2.1 to 30.0 g with a mean

Table 1

Statistics of the studied traits in the parental plants

Traits	No. of plants	Range	Mode	Mean	Standard deviation	Standard error	C. V.%
Weight of ten green fruits	421	2.1—30.0 g	3.05 g	7.20 g	6.44	0.31	89.44
Weight of ten red fruits	409	2.1—30.0 g	3.05 g	7.40 g	6.30	0.31	85.07
Volume of ten red fruits	450	4.9—84.8 cm^2	7.35 cm^3	17.20 cm^3	16.57	0.78	96.11
Number of main branches	695	1.9—14.8	5.35	6.2	2.10	0.80	33.82

Table 2

Statistics and heritability estimates of the progeny families

Traits	No. of families	Range	Grand mean	S. D.	S. E.	C. V.%	Heritability value, %
Weight of ten green fruits	38	2.3—17.4 g	4.0 g	2.65	0.43	65.59	64.36
Weight of ten red fruits	33	2.3—23.3 g	4.3 g	4.06	0.71	93.99	84.31
Volume of ten red fruits	27	3.0—33.2 cm^3	7.1 cm^3	6.24	1.20	88.26	84.92
Number of main branches	44	4.9—9.1	7.0	0.36	0.14	13.61	3.17

value of 7.4 g and a mode of 3.05 g. The standard deviation and coefficient of variability were 6.30 and 85.07% respectively. The range in volume of ten red fruits was from 4.9 to 84.8 cm^3 with a mean value of 17.2 cm^3 and a mode of 7.35 cm^3, while the standard deviation and coefficient of variability were 16.57 and 96.11% respectively. The other trait, number of main branches, showed considerable variation but to a lesser extent than was reported for the previous three characters. The number of main branches ranged from 1.9 to 14.8 with a mean value of 6.2 and a mode equal to 5.35. The standard deviation and coefficient of variation were 2.10 and 33.82% respectively.

The determination of the aforementioned characters in the progeny families indicated clearly and consistently a reduction in the variability as measured by the same biometrical constants estimated for the individual plants. The range, standard deviation and coefficient of variability was each decreased to a marked degree as shown in Table 2.

It must be emphasized, however, that the small number of families measured was an inadequate sample of the progeny family genotypes. Nevertheless, it may be noted that the results obtained for the families generally showed the expected trend relative to their respective parents.

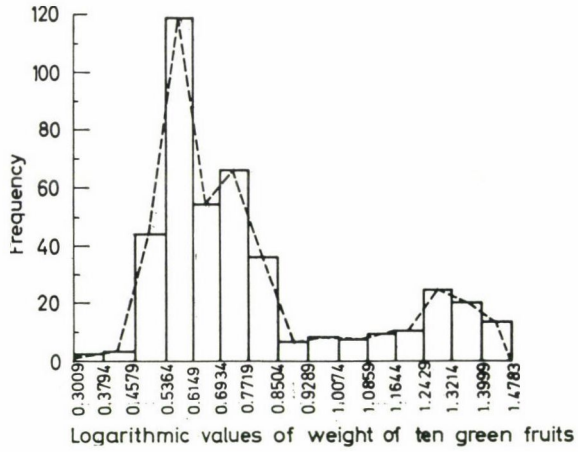

Fig. 1. Frequency distribution curve of weight of ten green fruits

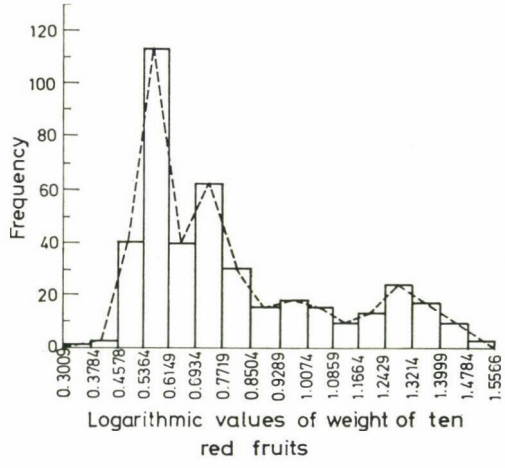

Fig. 2. Frequency distribution curve of weight of ten red fruits

The weight of ten green fruits ranged from 2.3 g to 17.4 g in the families, compared to 2.1 to 30.0 g in the parents. The coefficient of variation for the families was 65.59% compared to 89.44% in the parents.

The volume of ten red fruits ranged from 3.0 to 33.2 cm^3 in the families, while the range for the parents was 4.9 to 84.4 cm^3. The coefficient of variation for the families was 88.26% compared to 96.11% for the parents.

The number of main branches in the families ranged from 4.9 to 9.1 versus 1.9 to 14.8 in the parents. The coefficient of variation for this character in the families was 13.61% compared to 33.82% in the parents.

The trait weight of ten red fruits followed the same trend, but unexpectedly the coefficient of variation in the families was higher in magnitude than that reported for the parents. This contradiction could be the result of unbiased error.

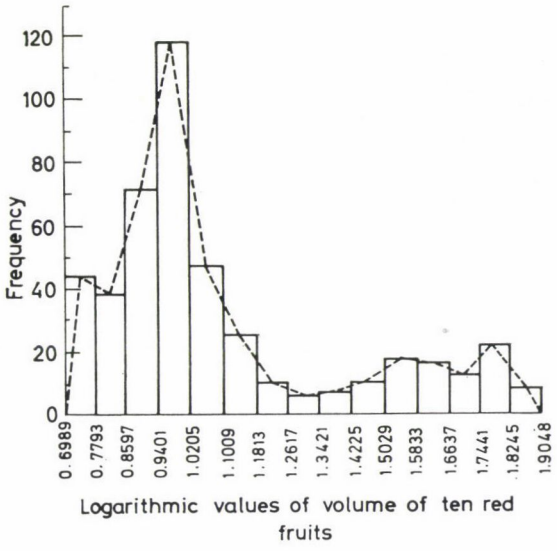

Fig. 3. Frequency distribution curve of volume of ten red fruits

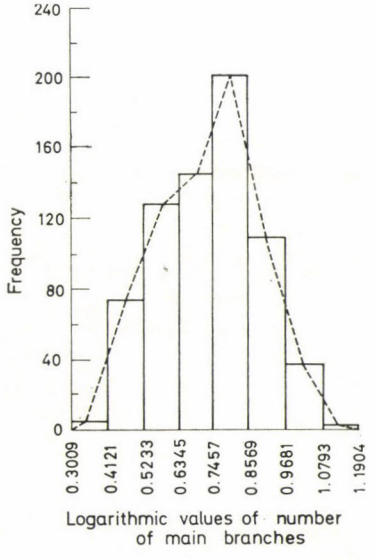

Fig. 4. Frequency distribution curve of number of main branches

These reductions in variabilities agreed with the view of JONES *et al.* (1928) and HARTMAN *et al.* (1960) that Capsicum is a frequently cross-pollinated plant due to varying degrees of cross pollination. It was pointed out by ODLAND—PORTER (1941) that cross-pollination in *Capsicum frutescens* may reach 16%. Thus, inbreeding in such cases depresses the genetic variability and leads to homozygous families.

Fig. 5. Different types of fruits collected from the parental plants

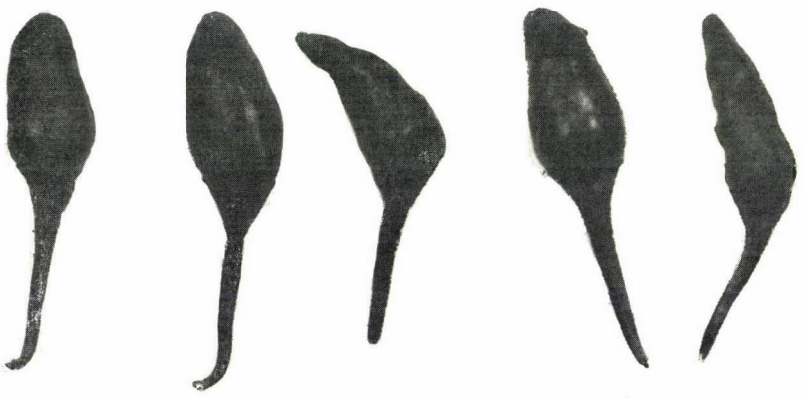

Fig. 6. Different types of fruits collected from the parental plants

Fig. 7. Different types of fruits collected from the parental plants

Fig. 8. Different types of fruits collected from the parental plants

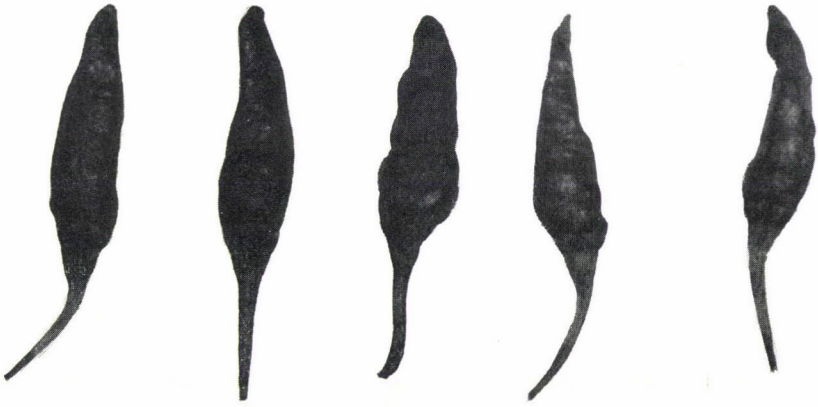

Fig. 9. Different types of fruits collected from the parental plants

Fig. 10. Different types of fruits collected from the parental plants

Parent–offspring regression was calculated as an estimate of the heritability value. Table 2 summarizes the heritability values for the characters studied. These results showed that the volume of ten red fruits, the weight of ten red fruits, and the weight of ten green fruits vary enough to signify the importance of the response of these characters to selection. The heritability values were 84.92%, 84.31% and 64.36% respectively. The above findings were supported by the results obtained by KHAMBANONDA (1950). He reported a 64% heritability for the size and weight of the fruits. Despite the high heritability values estimated for weight and volume traits, a low heritability value was nevertheless calculated for the number of main branches.

An examination of the frequency distribution curves of the traits studied indicated that the character with the lowest heritability value, i.e. the number of main branches, showed an almost normal distribution curve. This suggests a relatively large number of genes controlling it. However, the weight of ten green fruits, the weight of ten red fruits, and the volume of ten red fruits showed a skewness when their frequency distribution curves were presented. The skewness could be the result of a dominance effect from a relatively small number of genes combined with the high heritability values estimated for these characters. Dominance is clearly shown by the distribution to be in favour of low weight and volume, since the highest peak was in the direction of low values. These results were closely supported by KHAMBANONDA (1950) when he obtained a trimodal logarithmic distribution for fruit shape and weight in fourth generation hybrids. His conclusion that these characters are controlled by one gene is very similar to the predictions suggested by the present work.

By testing the arithmetic means of the characters examined, it was shown that the mean value of the number of main branches was not affected by inbreeding. However, the family means of the weight of ten green fruits, the weight of ten red fruits and the volume of ten red fruits were reduced by almost half the value estimated for the parents. This reduction in the means could be attributed to seasonal effects which characterized the progeny plantings, such as virus attacks, or to the dominance and epistatic effects of the large means. The results obtained from the frequency distribution curves agree with the former explanation, since dominance of the low values for weight and volume characterized the frequency distribution figures. Therefore, it was concluded that the reduction in the means was due almost entirely to seasonal pathological influences with a resultant decrease in the volume and weight of the fruits harvested.

All the characters studied showed a tremendous variability particularly in the traits: volume of ten red fruits, weight of ten green fruits and weight of ten red fruits, judged from their range of differences and coefficients of variance. These variabilities are of great significance to any further work aimed at a genetic advance in *Capsicum frutescens*.

The range of variability in the progeny families was less than in the parents. This is due to inbreeding effects. Such a process of inbreeding will introduce homozygous pure lines which could be a valuable genetic material for both breeding and the releasing of new varieties.

The determination of the heritability values showed that the weight and volume of the fruits have high heritability values. Apart from this, their frequency distribution curves suggested that these characters are controlled by a small number of genes.

Since the heritability values were fairly high for the weight and volume traits, these characters should be the basis for selection programmes.

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FLOWER-VISITING BEES IN LUCERNE FIELDS NEAR SZEGED

TYSDAL (1940, 1946) and BOHART (1957, 1960) reported on the flower-opening and pollinating activities of wild bees on lucerne. The investigations carried out by MÓCZÁR—BÖJTÖS (1957) in Hungary also proved the opening and cross pollinating activities of *Apoideae* in lucerne. Studies made at 27 sites in Hungary revealed the faunistic (MÓCZÁR 1961a), dominance and abundance (MÓCZÁR 1961b) relationships of *Apoideae* and the flower-visiting activities of the major species in Hungarian lucerne crops. The results of examinations performed in County Csongrád did not prove suitable for comparison with those obtained in other places. In County Csongrád repeated observations were therefore made in three lucerne fields in the neighbourhood of Szeged using the methods of the 1954—1956 national survey. The data obtained made it possible to evaluate the wild bees according to their flight period.

The lucerne fields were situated in the neighbourhood of Szeged and Újszentiván. The Újszentiván lucerne field was at a distance of 1 km from the point where the Hungarian, Yugoslav and Rumanian borders meet, in the immediate vicinity of the border. The investigations were made on 21st—22nd, 28th—31st July and 3rd—4th August 1971, 22nd—23rd, 25th, 27th—30th June and 1st—2nd, 4th July 1972. The lucerne crop occupied a 20.5 hectare heavily soiled area.

The sandy lucerne fields next to Szeged airport are situated 18 km west of the Újszentiván lucerne field. In 1971 a 57 hectare lucerne field on the northern side of the airport, and in 1972 a 19.4 hectare field on the western side were examined. The dates of examinations were: 23rd—27th July, 2nd, 5th August 1971; 22nd—23rd, 25th, 27th—30th July and 1st—2nd, 11th August 1972.

As regards the quantitative relationships of wild, flower-visiting bees in lucerne conclusions were drawn from strip surveys made between 9 and 10 a.m. every day. In a rectangular strip of land 1 m wide and 10 m long the number of *Apoideae* flying in was recorded for 30 seconds per m^2, on 10 occasions a day if possible. The daily sites of surveying were evenly distributed in the lucerne field in a transverse direction. For the qualitative examinations of *Apoideae*, collections were made for 30 minutes each between 11 a.m. and 12 noon, and between 2 and 3 p.m. Meteorological data for the days of examinations are shown in Figs 1 and 2.

I. Abundance conditions in lucerne fields. In the course of strip surveys made on 18 occasions during 1971—1972 on an area of 1740 m^2 in the Újszentiván lucerne field the appearance of 1247 wild bees was recorded, which suggests the presence of 71.66 specimens on a daily average, 7.17 on an average of 10 m^2, and 7170 on a hectare. The number of wild bees in strip surveys made on 17 occasions in 1971—1972 over an area of 1680 m^2 at Szeged was 568, i.e. 33.8 on a daily average, 3.38 on an average of 10 m^2 and 3380 in 1 ha.

The examined areas differ substantially in wild bee frequency. The wild bee abundance in the Újszentiván area was more than double that of the lucerne fields near Szeged. This

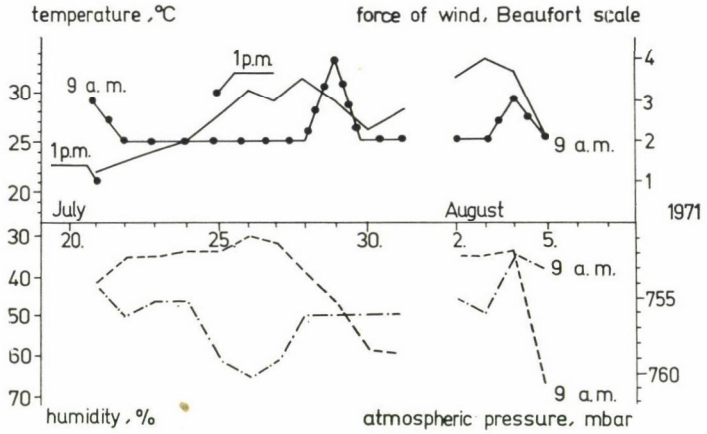

Fig. 1. Meteorological data on the days of examination in 1971, at 9 a.m. and 1 p.m. (——— temperature, ... wind force, · · · · · atmospheric pressure, - - - - humidity)

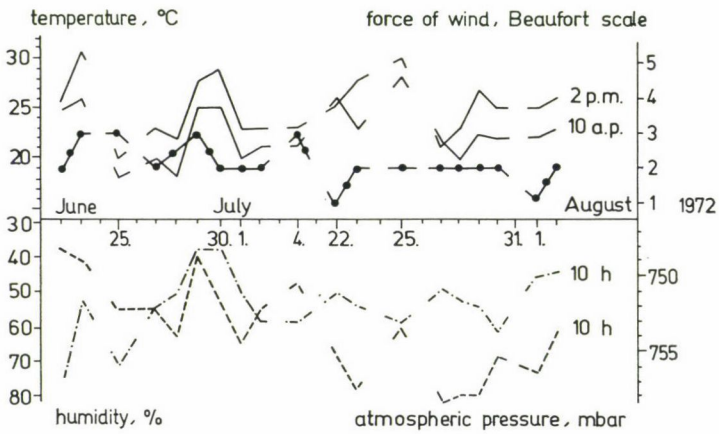

Fig. 2. Meteorological data on the days of examination in 1972, at 10 a.m. and 2 p.m. (——— temperature, ... wind force, · · · · · atmospheric pressure, - - - - - - humidity)

was due first of all to the favourable environmental conditions of the former. The incorrect application of insecticides also contributed to the low individual number of wild bees at Szeged.

To sum up the results obtained on the two lucerne areas: in 1971—1972 surveys were made on 35 occasions on a total area of 3420 m², in the course of which 1815 wild bees — 53.07 on a daily average and 5.31 on an average of 10 m² — were recorded. This indicates the presence of 5307 wild bees on 1 ha in the lucerne fields around Szeged. This individual density of 5307 wild bees per ha is a considerably higher abundance value than the 1954—1956 mean, so when comparing it with the results of observations made in other parts of Hungary we can establish that in 1971—1972 the wild bee abundance was higher in the Hajdúság and Nagykunság (east of the river Tisza) and in the Kiskunság (between the Danube and Tisza) and lower in the counties Somogy, Fejér, Békés and Baranya and in the Hanság (the region of Lake Fertő) than in County Csongrád.

According to BENEDEK (1970) the results obtained by Móczár's stris survey method, employed in the abundance examinations described in this paper, and by the simple strip survey are not identical. Móczár's method gives higher abundance values. The difference is due to the motion of the wild bees. When there is a lower abundance of wild bees the difference between the results of the two methods is smaller, while with a higher abundance it is larger. The simple strip method is suitable for static abundance examinations, where the time factor is not taken into consideration.

II. Dominance conditions. A total of 71 *Apoidea* species were identified, 63 by collecting and 8 by observations on flower-visiting. The occurrence of wild bees collected in the course of dominance examinations is shown in Table 1 according to the place of collection. In the course of observations made on flower-visiting in the lucerne fields near Szeged, *Colletes daviesanus* Sm. and *Halictus morbillosus* Kriechb. occurred as single specimens in 1971, and *Halictus smaragdulus* Vach., *Halictus veneticus* Blüthg., *Megachile pilidens* Alfk., *Megachile rotundata* F., *Tetralonia hungarica* Friese and *Eucera nitidiventris* Mocs. in 1972.

In the Újszentiván lucerne fields 49 species were collected and 37 from lucerne flowers at Szeged. The range of species was substantially broader at Újszentiván than at Szeged. This could be attributed to the following conditions: heavy soil favourable for nesting, diversified culture and weed flora, uniform density of lucerne. The number of wild bee species in the lucerne fields around Szeged is noteworthy: in the course of collections carried out in 1954—1956 all over Hungary MÓCZÁR (1961a) described 98 species.

At Újszentiván we collected 667 specimens over 18 days to determine the dominance.

Dominant species: *Halictus malachurus* K. 11.69%.

Subdominant species: *Bombus agrorum* F. 10.49%, *Halictus eurygnathus* Blüthg. 9.30%, *Melitta leporina* Pz. 8.25%.

At Szeged 478 bees were collected in 17 days for the purpose of establishing the dominance conditions.

Dominant species: *Melitta leporina* Pz. 20.71%.

Subdominant species: *Andrena ovatula* K. 18.20%, *Melitturga clavicornis* Latr. 16.11%.

The result of collecting for 35 days in 1971—1972 in the lucerne fields of Újszentiván and Szeged was 1145 wild bees. The totalled dominance values were:

Dominant species: *Melitta leporina* Pz. 13.45%.

Subdominant species: *Andrena ovatula* K. 12.14%, *Melitturga clavicornis* Latr. 8.12%.

The detailed dominance values are given in Table 2.

According to investigations made in Hungary, of 600 wild bee species some 150 visit lucerne stands (MÓCZÁR 1961a, BENEDEK 1968b, 1969). According to BENEDEK (1966) of the useful wild bees 20 species are of practical importance. As a result of investigations carried out by MÓCZÁR (1961c) the following species were found to be dominant: *Melitta leporina* Pz. in Transdanubia; *Eucera clypeata* Er. in County Fejér, on the Great Hungarian Plain (County Szolnok) and over a large part of the area east of the Tisza; and *Andrena ovatula* K. in the Hajdúság. In counties Csongrád and Baranya — that is in the southernmost parts of Hungary — *Melitta leporina* Pz. and *Melitturga clavicornis* Latr. were the most important species (MÓCZÁR 1956, 1961c). This seems to be confirmed by the investigations made in the neighbourhood of Szeged.

III. Distribution of Apoideae by flight period. According to the length of the flight period (BENEDEK 1968a, 1968c) the wild bees can be placed in 3 main groups: species with a short, a medium and a long flight period. Species with a short and medium flight period have one generation a year, while those with a long flight period have two. Within the long flight period group bivoltin species and those with continuous reproduction may be distinguished. The material collected in our investigations for the determination of dominance was used to point out the number of *Apoideae* in the different regions according to flight

Table 1

Occurrence by locality of wild bee species collected from lucerne flowers

Species	Locality	
	Újszentiván	Szeged
Melitta leporina Pz.	+	+
Andrena flavipes Pz.	+	+
Andrena labialis K.	+	+
Andrena carbonaria L.	—	+
Andrena ovatula K.	+	+
Andrena variabilis Sm.	+	—
Andrena species	+	+
Nomada fucata Pz.	+	—
Nomada species	+	—
Halictus quadricinctus F.	+	+
Halictus rubicundus Christ.	+	—
Halictus patellatus Mor.	+	—
Halictus maculatus Sm.	—	+
Halictus simplex Blüthg.	+	—
Halictus eurygnathus Blüthg.	+	+
Halictus tetrazonius Klug.	+	+
Halictus subauratus Rossi	+	—
Halictus leucozonius Schrk.	+	+
Halictus interruptus Pz.	—	+
Halictus calceatus Scop.	+	+
Halictus marginatus Brüllé	+	—
Halictus laticeps Schck.	+	+
Halictus malachurus K.	+	+
Halictus quadrisignatus Schck.	+	—
Halictus species	+	—
Sphecodes species	—	+
Rhophites pillichi Blüthg.	—	+
Rhophites quinquespinosus Spin.	+	—
Rhophitoides canus Ev.	+	—
Systropha curvicornis Scop.	—	+
Systropha planidens Gir.	+	—
Megachile argentata F.	+	+
Megachile centuncularis L.	+	+
Megachile ericetorum Lep.	—	+
Megachile maritima K.	+	+
Megachile versicolor Smith.	+	—
Osmia atrocoerulea Schill.	+	—

Table 1 continued

Species	Locality	
	Újszentiván	Szeged
Osmia aurulenta Pz.	+	—
Anthidium manicatum L.	—	+
Coelioxys afra Lep.	—	+
Tetralonia armeniaca Mor.	+	—
Tetralonia pollinosa Lep.	+	—
Eucera cinerea Lep.	+	—
Eucera clypeata Er.	+	+
Eucera interrupta Baer	+	—
Eucera longicornis L.	+	—
Eucera pollinosa Smith.	+	—
Eucera similis Lep.	—	+
Melitturga clavicornis Latr.	+	+
Anthophora quadrifasciata Vill.	—	+
Xylocopa violacea L.	+	—
Bombus agrorum F.	+	+
Bombus derhamellus K.	—	+
Bombus helferanus Seidl.	+	+
Bombus hortorum L.	+	—
Bombus lapidarius L.	+	+
Bombus laesus mocsáryi Kriechb.	+	—
Bombus muscorum F.	+	—
Bombus ruderatus eurynotus Kriechb.	—	+
Bombus silvarum distinctus Vogt.	+	+
Bombus terrestris L.	+	+
Psithyrus barbutellus K.	—	+
Apis mellifica L.	+	+

Note: + species collected; — species not collected

period. The evaluated stock consisted of 1143 bees, 666 obtained from Újszentiván and 477 from Szeged. *Nomada* sp. collected in 1972 at Újszentiván and the species *Sphecodes* found at Szeged are not included in the evaluation. The distribution of flight groups by number of individuals and as a percentage for the different areas separately and together is shown in Table 3.

At Újszentiván the bulk of the pollinating wild bee stock was formed by long flight period bivoltin species *(Halictus* and *Andrena)*, while at Szeged the short flight period wild bees (*Melitta leporina* Pz., *Melitturga clavicornis* Latr.) were prevalent. This can be explained by the fact that while the individual number of *Andrena* and *Halictus* was high at Újszentiván, under the influence of heavy soil and diversified culture and weed flora, at Szeged *Melliturga clavicornis* Latr., a wild bee frequently found on lucerne on sandy areas, occurred in large numbers together with *Melitta leporina* Pz. Species with a medium flight period were

Table 2

Percentage dominance

Species	Újszentiván	Szeged	Totalled dominance values
	%		
Melitta leporina Pz.	8.25	20.71	13.45
Andrena flavipes Pz.	7.35	5.86	6.72
Andrena labialis K.	5.55	1.46	3.81
Andrena ovatula K.	7.80	18.20	12.14
Andrena variabilis Sm.	1.35	0.00	0.79
Andrena carbonaria K.	0.00	0.84	/<0.50/
Halictus malachurus K.	11.69	/<0.50/	7.07
Halictus eurygnathus Blüthg.	9.30	4.81	7.42
Halictus tetrazonius Klug.	6.15	1.67	4.28
Halictus calceatus Scop.	1.35	/<0.50/	0.96
Systropha curvicornis Scop.	/<0.50/	1.05	/<0.50/
Megachile argentata F.	1.50	2.72	2.01
Megachile maritima K.	/<0.50/	/<0.50/	0.61
Eucera clypeata Er.	4.20	2.30	3.41
Eucera pollinosa Smith.	1.35	0.00	0.79
Melitturga clavicornis Latr.	2.40	16.11	8.12
Bombus agrorum F.	10.49	3.14	7.42
Bombus lapidarius L.	2.85	5.02	3.76
Bombus silvarum distinctus Vogt.	4.20	/<0.50/	2.71
Bombus terrestris L.	5.10	7.74	6.20
Other species	9.12	8.37	8.33
	100.00	100.00	100.00

Table 3

Distribution of Apoideae by flight period

Flight groups	Újszentiván		Szeged		Total	
	number	%	number	%	number	%
Short flight period pollinators	92	13.80	210	44.02	302	26.43
Medium flight period pollinators	52	7.86	12	2.53	64	5.59
Long flight period bivoltin pollinators	363	54.54	172	36.05	535	46.80
Long flight period pollinators with continuous reproduction	159	23.80	83	17 40	242	21.18

present in the lowest numbers on both areas. The proportion of medium flight period species to the total number of pollinating bees collected was three times as high at Újszentiván as at Szeged. This was probably due to the better nesting and feeding conditions existing at Újszentiván. To some extent the diversified culture and weed flora provides a permanent source of nutrition, and the heavy soil with its favourable nesting conditions promotes the multiplication of species belonging to the genera *Eucera* and *Tetralonia*. The proportion of the continuously flying long flight period *Bombus* species to the total wild bee population was larger at Újszentiván than at Szeged.

In the lucerne fields in the neighbourhood of Szeged nearly half of the pollinating bee population consisted of long flight period, bivoltin species. The smallest proportion of the pollinating wild bee population found on the lucerne flowers was represented by species with a medium long flight period. Our results were similar to those obtained by BENEDEK (1969) in the Great Hungarian Plain (counties Pest, Szolnok, Hajdú, Békés). According to Benedek the most important lucerne pollinators in counties Hajdú and Békés were found to be the long flight period bivoltin species, and in Pest and Szolnok the short flight period summer species. Species with a medium long flight period were represented by the smalless number of individuals on all the areas examined (BENEDEK 1969).

Benedek's data for counties Békés, Hajdú, Pest and Szolnok, supplemented with the results of investigations made in county Csongrád, show that in the Great Hungarian Plain the long flight period bivoltin, and the short flight period wild bee species form the bulk of the population pollinating lueerne.

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CONTROL STUDIES ON MITES ASSOCIATED WITH PEA IN THE U.A.R.

The pea crop has occupied an important position among the locally grown vegetables. The newly reclaimed land in Tahreer Province has a characteristically excellent soil for pea cultivation, 2730 hectares were devoted to the cultivation of this crop alone. During the last decade, pea crop growers all over the country have complained very much about the deterioration of pea plants and about the great losses suffered in the crop.

The most troublesome limiting factors in increasing the cultivated lands for this crop in Tahreer Province are mites, insects, and mildew diseases.

The purpose of this research is to carry out further experiments to study firstly the mites which attack pea plants and cause serious damage, and secondly the suitable time and possible means of control in Tahreer Province.

An area of 2.1 hectares cultivated with pea plants of the variety little Marvel was chosen for this investigation. Experiments were carried out during two seasons. Pea plants were cultivated during the seasons at the beginning of October. Samples of 100 leaves were collected at random from the four replicates of each treatment and were examined carefully. For the second season certain acaricides and fungicides were tested for controlling the mites and mildew diseases (Table 1). The temperature and moisture degrees were estimated during the two seasons. Regarding the yield, pods of green peas were collected and weighed at the end of the season.

The purpose of this research is to record the mites associated with pea plants. Species of mites collected from pea leaves during the two seasons are shown in Table 2.

These species were identified, one family being classified as phytophagous, two families as predacious and one family as phytophagous or predacious.

Tetranychus urticae (*T. cucurbitacearum* Sayed) was the most serious mite throughout this study, followed by *Eutetranychus orientalis* (Banks) and *Tetranychus arabicus* (Attiah).

The damage is caused by sucking the plant sap, causing small yellow blotches to develop. These blotches, however, gradually enlarge, depending upon the increase of feeding, and change to reddish brown. The mites spin large amounts of webbing forming a sheath over the leaf surface. Being full of dust carried by the wind, this sheath reduces the respiration and photosynthesis of the leaf. Finally, infested leaves change to a rusty brown colour.

As a result of infestation the pea plants were weakened, their growth in general was diminished and they gave a very poor quantity of green pods (Fig. 1).

Table 1

Chemicals used in the second season

Chemicals	Rate of application, %	Formula
Nogos E. C. 50%	0.150	0.0 dimethyl 2—2 dichlorovinylphosphate
Kelthane E. C. 18.5%	0.250	1,1 bis (chlorophenyl) 2,2,2 — trichlorocthanol
Dithane M. 45 W. P.	0.259	Ethylene bisdithiocarbamate ..... 62% Manganese ..... 16% Zinc ..... 2% Inert ingredients 20%
Colloidal sulphur	0.250	Colloidal sulphur 80%
Nogos + Dithane M. 45	0.150 + 0.250	
Kelthane + Dithene M. 45	0.250 + 0.250	

Fig. 1. Pea plants injured by mites (A)

Table 2

Mites associated with pea plants in Tahreer Province

Families	Scientific name	Feeding habit
Tetranychidae	*Tetranychus cucurbitacearum* (Sayed)	*Phytophagous*
	Tetranychus arabicus (Attiah)	*Phytophagous*
	Euteranychus orientalis (Banks)	*Phytophagous*
Phytoseiidae	*Typhlodromus* spp.	*Predacious*
Cheyletidae	*Cheyletia* spp.	*Predacious*
Tydeidaee	*Tydeus* spp.	*Phytophagous* or *predacious*

Table 3

Accumulated average number of Tetranychus urticae (T. cucurbitacearum (Sayed)) per leaf

Chemicals	Before Spraying	First Spray			Second Spray			Third Spray			Total
		1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	
		count									
Nogos E. C. 50%	15	5	4	1	1	2	0	0	0	0	28
Kelthane E. C. 18.5%	17	9	5	2	4	3	0	0	0	0	40
Dithane M. 45 (W. P.)	20	14	11	8	10	5	3	8	2	5	86
Colloidal sulphur	16	10	8	6	14	11	9	13	6	8	100
Nogos + Dithane	21	6	1	2	0	0	0	0	0	0	30
Kelthane + Dithane	18	10	5	3	0	0	0	0	0	0	36
Control	15	20	24	27	33	40	30	25	28	23	265

L. S. D. 0.05 = 6.1334
0.01 = 9.4235

Examination of the above phytophagous mites during the second season, proved that the acaricide Nogas E.C. 50% mixed with the fungicide Dithane M. 45 were the most effective for controlling the mites and mildew diseases, followed by Kelthane E.C. 18.5% mixed with Dithane M. 45 (Tables 3, 4, 5).

Although, the acaricides Nogos and Kelthane gave a good result for controlling the mites, the fungicide Dithane M. 45 must be added to obtain the best yield (Table 5).

Regarding the predacious mites, it was noticed that they have no significance in controlling the phytophagous mites.

These results confirmed the data obtained by OSMAN (1974), OSMAN—SOLIMAN (1974), JEPPSON—CARMAN (1974), PATTERSON *et al.* (1974), EL-ATROUZY (1968) and HASSAN *et al.* (1959).

Table 4

Accumulated average number of Eutetranychus orientalis (Banks) per leaf

Chemicals	Before Spraying	First Spray			Second Spray			Third Spray			Total
		1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	
		count									
Nogos E. C. 50%	8	3	2	1	2	2	0	0	0	0	18
Kelthane E. C. 18.5	10	6	3	2	4	2	1	0	0	0	28
Dithane M. 45 (W. P)	9	5	4	2	3	1	2	2	3	2	33
Colloidal sulphur	8	6	4	2	5	3	2	3	2	5	40
Nogos + Dithane	11	2	1	1	0	0	0	0	0	0	15
Kelthane + Dithane	7	3	2	4	3	2	1	0	0	0	22
Control	9	11	14	14	15	30	18	17	15	16	149

L. S. D. 0.05 = 8.4251
0.01 = 11.3672

Table 5

Accumulated average number of Tetranychus arabicus (Attiah) per leaf

Chemicals	Before spraying	First spray			Second spray			Third spray			Tota
		1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	
		count									
Nogos E. C. 50%	5	2	1	1	0	0	0	0	0	0	9
Kelthane E. C. 18.5%	8	3	2	1	1	1	0	0	0	0	18
Dithane M. 45 W. P.	10	8	3	1	1	1	1	1	1	1	28
Colloidal sulphur	5	3	2	2	3	2	1	1	1	1	21
Nogos + Dithane	6	1	0	0	0	0	0	0	0	0	7
Kelthane + Dithane	9	2	1	1	0	0	0	0	0	0	13
Control	6	6	7	8	10	11	13	15	12	16	104

L. S. D. 0.05 = 4.3675
0.01 = 6.2134

In the family *Tetranychidae*, however, the frequency of the resistance phenomenon in mites is greatest. Undoubtedly this is because of the great economic importance of the spider mites. As a consequence they have been under greater chemical stress than other groups. In many situations the tetranychids were promoted from the role of a minor pest to that of a major pest as a result of DDT. They have remained in this position because of resistance.

Nevertheless, it is useful to draw attention to the fact that other agricultural mite pests have not responded with resistance, even after more than ten years of chemical control. This is certainly true of a family related to the *Tetranychidae*, the *Phytoptipalpidae*, of which

several species are of economic importance. Resistance could also be expected in another family. During the past ten years, however, Op. compounds — Kelthane, endrin, and endosulfan — have been used against Tarsonemid pest, without a control failure caused by resistance (HELLE 1970).

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EXPERIMENTS AIMED AT PRODUCING HYBRID LUCERNE. I. STERILITY AND FERTILITY STUDIES

The primary aim of plant breeding is to produce new varieties with the highest possible productivity and composition value. Of the methods employed for this purpose heterosis breeding using a male sterile basic material has come into prominence (ZIMOVA 1966). The use of male sterile mother plants is of importance first of all in plant species where hybrids can otherwise be produced only by castration.

Male sterility has been studied and used in almost all agricultural plant species. A number of authors have dealt with this question in Hungary too: CSETNEKI (1965) and NAGY *et al.* (1969) in maize, BARABÁS (1962) in sorghum, ANDRÁSFALVY—BÁLINT (1969) in onion and ASZTALOS (1968), ANDRÁSFALVY (1969) and LUN (1969) in tomato. ANDRÁSFALVY (1969) observed occasional differences between male sterile and fertile flowers of the tomato in the colour of flower, width of pollen tube and size of pistil.

The discovery and utilization of male sterile lucerne were reported by CHILDERS—MCLENNAN (1960). The sterile clone described by them under the name 20DRC maintained its sterility both in the field and under greenhouse conditions. F_1 plants produced by crossing the 20DRC clone with fertile plants showed an intermediary course of inheritance according to the extent of sterility.

The male sterility disclosed by Childers is genic in nature (KRUPNOV 1973). Lucerne with unviable pollen was first found in 1948 by Almanyizovum (Soviet Union), but the utilization of the male sterile factor was started much later by Lubenec and Nago-Vishchina (VENGRENOVSKY—TERESHCHENKO 1969). In 1968 Bradner and Childers described the clone

Oms-5, which shows a cytoplasmic transmittance of sterility and is nulliplex as regards male sterility (TERESHCHENKO—SIMONENKO 1971).

VENGRENOVSKY—TERESHCHENKO (1969) studied the effect of cultural conditions on pollen sterility in lucerne. The experiment carried out by them showed that the sterility percentage of pollens in male sterile plants varied with the weather conditions and the age of the plant. At reduced temperatures and increased humidity the extent of pollen sterility decreases both under field and greenhouse conditions.

In the course of her investigations KONSTANTINOVA (1970) tried to find out what fertile plants should be crossed with the given sterile clone in order to attain the most favourable heterosis effect. She found that the seemingly most suitable sterile plant chosen from the population of a locally bred or commercially produced variety was the best initial material, while, as pollen parents, improved varieties originating from geographically distant lucerne areas proved optimum. Good results were generally obtained when crossing varieties with great ecological, geographical and genetic differences.

DAVIS—GREENBLATT (1967), having examined nearly 50 thousand plants, found 28 plants of which 4 were totally and 9 partially sterile. Studies on the transmittance of aborted pollen in the first four plants showed that each of them was a type of cytoplasmic male sterility. Plants with cytoplasmic male sterility considerably differ from those with genic male sterility as regards the extent of pollen development and the mechanism of transmittance. In genically sterile clones the anthers are perfectly empty; in clones with a cytoplasmic sterility the pollen grains, though present, are aborted (KRUPNOV 1971).

TERESHCHENKO—SIMONENKO (1971) carried out comparative studies on anthers in fertile and sterile plants. The two kinds of anther are morphologically different. The anthers of sterile clones are whitish, of uneven, loose structure, without turgor. In fertile clones the anthers are larger, yellowish and more compact. Cytological analyses showed that normal tetrads develop, followed by uninuclear microspores in both cases. Later the anthers are different in accordance with the size of the loculi. In sterile anthers the loculi are twice as small as in fertile ones. In sterile anthers the septa do not disappear and the anthers have four loculi up to the end of the development.

Fertile anthers often consist of two loculi grown together; they are perfectly round, have three pores, normal size pollen, and in many cases a small amount of unviable pollen.

Among the Hungarian authors the structure of the lucerne flower, the methodology of studies on flowering and fertilization biology, and the situation of hybrid lucerne production have been dealt with by BŐJTÖS (1960, 1961, 1971, 1973), HESZKY (1970, 1971) and SULYOK (1970).

To point out sterile and fertile pollens and ascertain the sterile nature of a plant, the carmine-acetic acid method, the iodine-potassium iodide method and Alexander's pollen staining method are used as well as pollen germination in a 10% sugar solution.

The search for a sterile basic material was carried out in our trial plot and in large-scale fields. For three years some 20 thousand plants were examined in the field and about a thousand under the microscope every year. The sterility percentage was determined with the carmine-acetic acid method and Alexander's pollen staining technique as well as by pollen germination (Figs. 1 and 2). In both pollen staining methods the extent of staining was taken into consideration when establishing our data.

Pollen germination was carried out in a 10% sugar solution to which 0.1 mg boric acid (H_3BO_3) was added to delay the development of fungi. From this solution a suspension drop preparation was made for the microscopic examination. Within 30 minutes after preparation the appearance of the pollen tube was clearly seen.

A detailed microscope examination in the laboratory decides whether the plants previously marked out in the field can be used for further breeding work. We always used fresh

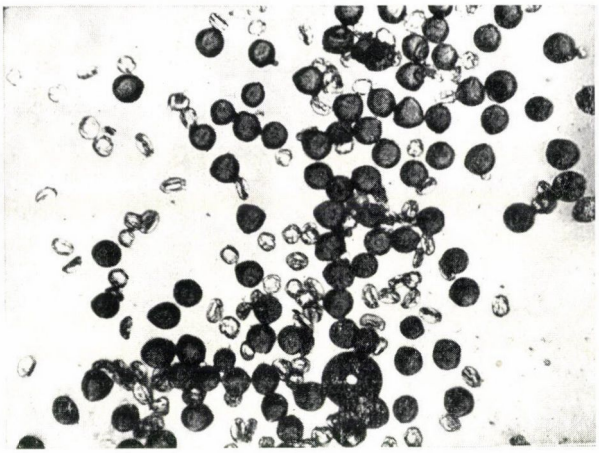

Fig. 1. Pollen staining with carmine-acetic acid (dark stained fertile and transparent sterile pollens can be distinguished well)

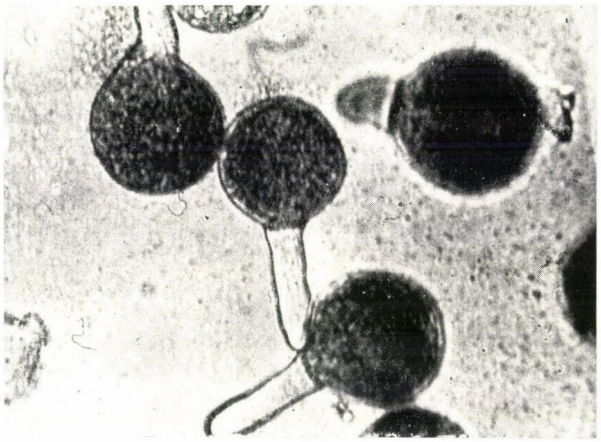

Fig. 2. Pollen germination (30 minutes after the preparation had been completed)

flowers for the examinations and did not apply any fixation technique. With both pollen staining methods the number of viable and aborted pollens for each preparation made from the pollen mass obtained from several flowers in a cluster was determined in 10 fields of sight, magnified ×100 by the microscope. The above mentioned staining methods were also used in establishing the sterility percentage of F_1 plants produced by crossing.

The detected sterile mother plants were propagated vegetatively. The selected sterile plants were dug out together with the surrounding earth and placed in pots, after which cuttings were taken from them. On the first occasion 30—50 cuttings were obtained from each plant. The stem and top cuttings were placed in test-tubes filled with rainwater. Rooting took 4—5 weeks. The rooted cuttings were transplanted into boxes and pots and in the greenhouse. Each sterile clone was examined in the greenhouse. Next spring the examined sterile

Table 1

Distribution of the combinations produced according to sterility percentage

Designation	0—50	51—60	61—70	71—80	81—90	91—100	Total number of combinations
	per cent						
Combinations of mother plant							
No. 1	27	26	19	12	2	2	88
No. 2	9	22	41	49	37	3	161
No. 3	34	10	6	1	1	—	52
No. 4	—	—	2	3	12	—	17
Total	70	58	68	65	52	5	318

clones were placed in a trial plot, then at the time of flowering individually isolated. F_1 combinations were produced by hand crossing.

To study the inheritance of sterility and select the plants that fix the sterility we pollinated at least 20—25 clusters for each combination in order to obtain an amount of seed sufficient to determine the sterility of the F_1 generation. Exact data on the sterility of a combination can only be obtained by examining 25—30 F_1 plants within the combination.

Subsequently we studied the seed setting capacity of the sterile mother plants. For this purpose the pollinated clusters were labelled. With the mature cochleae unfolded we established first the number of cochleae, then the number of flowers, from the stumps of the flower stems, which can be clearly seen on the floral axis even in a mature stage, corrected by the data on the labels, and finally the number of seeds. In possession of these data we determined the fertilization percentage. This calculation was made first for a cluster, then for a combination. Finally we summarized the data of combinations per mother plant.

1. *Sterility transmittance in sterile mother plants.* In searching for a sterile basic material we found several plants with 99—100% sterility. After repeated selection we were left with 8 sterile plants. Having found the sterile mother plants we began crossing with the purpose of searching for pollen parents which fix the sterility. The fertile pollen parents used in the experiment were chosen from Hungarian and foreign inbred strains and varieties. With sterile mother plants a total of 548 F_1 combinations were produced. The extent of sterility transmitted to F_1 plants originating from crossings with the sterile mother plants Nos 1, 2, 3 and 4 is presented in Table 1. The data in the table were obtained by pollen staining with carmine-acetic acid.

The data contained in the table show that practically no pollen parents were found which, when crossed with the sterile mother plant No. 3, would produce sterile F_1 plants. Of the combinations produced with mother plant No. 1, again only a few show sufficient sterility. The 40 combinations obtained with mother plant No. 2 belong to the 80—100% sterility category. According to the data referring to mother plant No. 4 this sterile plant has a high capacity for transmitting this property. Of the combinations produced 70% have proved to be practically sterile.

In the course of evaluating the combinations produced we can establish that a number of the F_1 combinations available may serve as a satisfactory basic material for hybrid production. To be able to compare the transmitting ability of sterile mother plants we crossed them with the same fertile pollen parents. For the sterile plants Nos. 1 and 2 the results of comparison are shown in Fig. 3. The data were obtained by pollen staining.

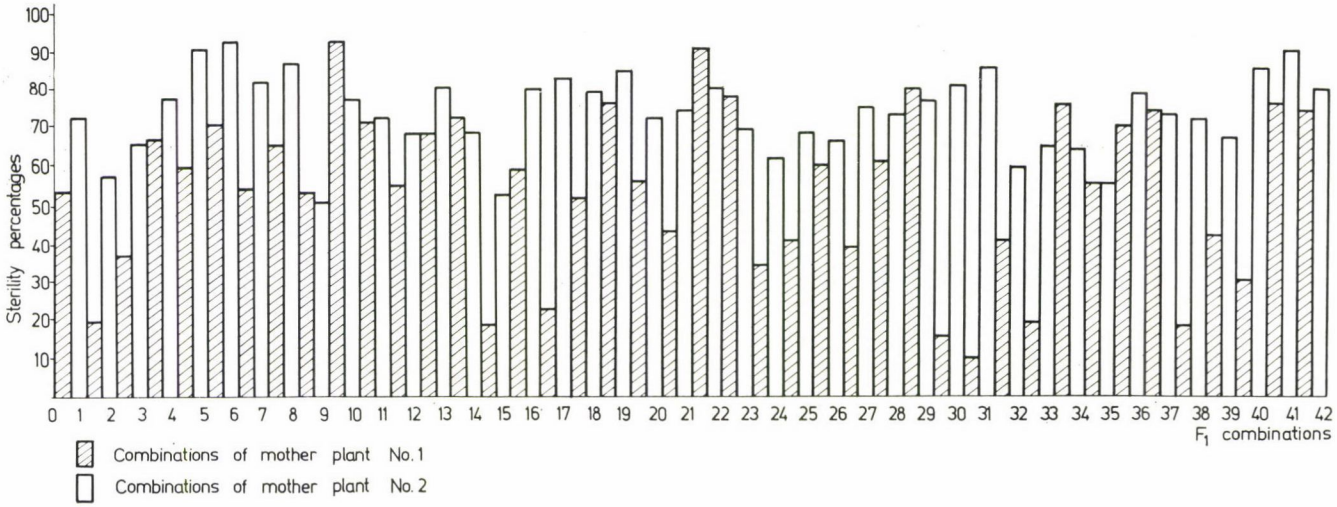

Fig. 3. Sterility percentages in F_1 combinations of sterile mother plants

The figure clearly shows that in the case of crossing with the same pollen parent the sterile plants give different responses. It happened that with sterile plant No. 1 the fertile pollen parent produced F_1 plants with only 50% sterility, while with No. 2 the F_1s were sterile in 92%. Even if a pollen parent maintains sterility at a high level with one of the mother plants we cannot be sure that the result will be the same with another mother plant.

2. *Seed setting in sterile mother plants.* Low seed production is generally known to be the great trouble of hybrid lucerne production. This phenomenon already appears in the first phase of hybrid production: in the basic material production. Therefore, to be able to choose the best F_1 combinations as regards seed production we determined the seed setting ability of the mother plants. This property implies both the fertility of the mother plant and the potential of the pollen donor. The relevant data are seen in Table 2.

Table 2

Seed setting ability of mother plants

Designation	Number of crossed flowers	Number of pods	Number of seeds	Seed setting percentages,	Number of seeds per pod,
	n			%	n
Combinations of mother plant					
No. 1	14,039	2,294	2,665	20.2	1.2
No. 2	23,271	10,114	31,077	36.2	3.1
No. 3	4,454	1,837	3,717	41.2	2.1
No. 4	5,998	2,725	9,758	45.4	3.5
No. 5	4,074	1,146	2,473	28.1	2.1
No. 6	892	282	337	31.6	1.2
No. 7	875	164	211	18.7	1.3
No. 8	1,485	708	1,751	47.6	2.5

As regards the number of seeds per pod and the percentage of seed setting, Nos 2 and 4 again seem to be the most promising sterile plants.

In our experiment seed setting was better in the greenhouse than in the trial plot, and the number of seeds per pod was also higher. This may be due first of all to the fact that in the greenhouse the optimum conditions for crossing can easily be ensured: about 57% relative humidity, 23—25°C temperature, 8—10 thousand lux light intensity and 14 hours of illumination.

We have already referred to the importance of choosing the right parent partners. With a view to a better understanding Fig. 4 shows the percentage trend of seed setting obtained by crossing two sterile mother plants and the same 80 pollen parents on a column diagram. The figure clearly shows the superiority of mother plant No. 2 over No. 1.

When choosing pollen parents to be used for crossing, besides the different origin we took into consideration the production and composition values of the strains marked out. From 1973 onwards we also used plants proved to be resistant to *Fusarium oxisporum* SCHL. and *Verticillium albo-atrum* REINHE et BERTH. in the course of infection experiments carried out at our Institute.

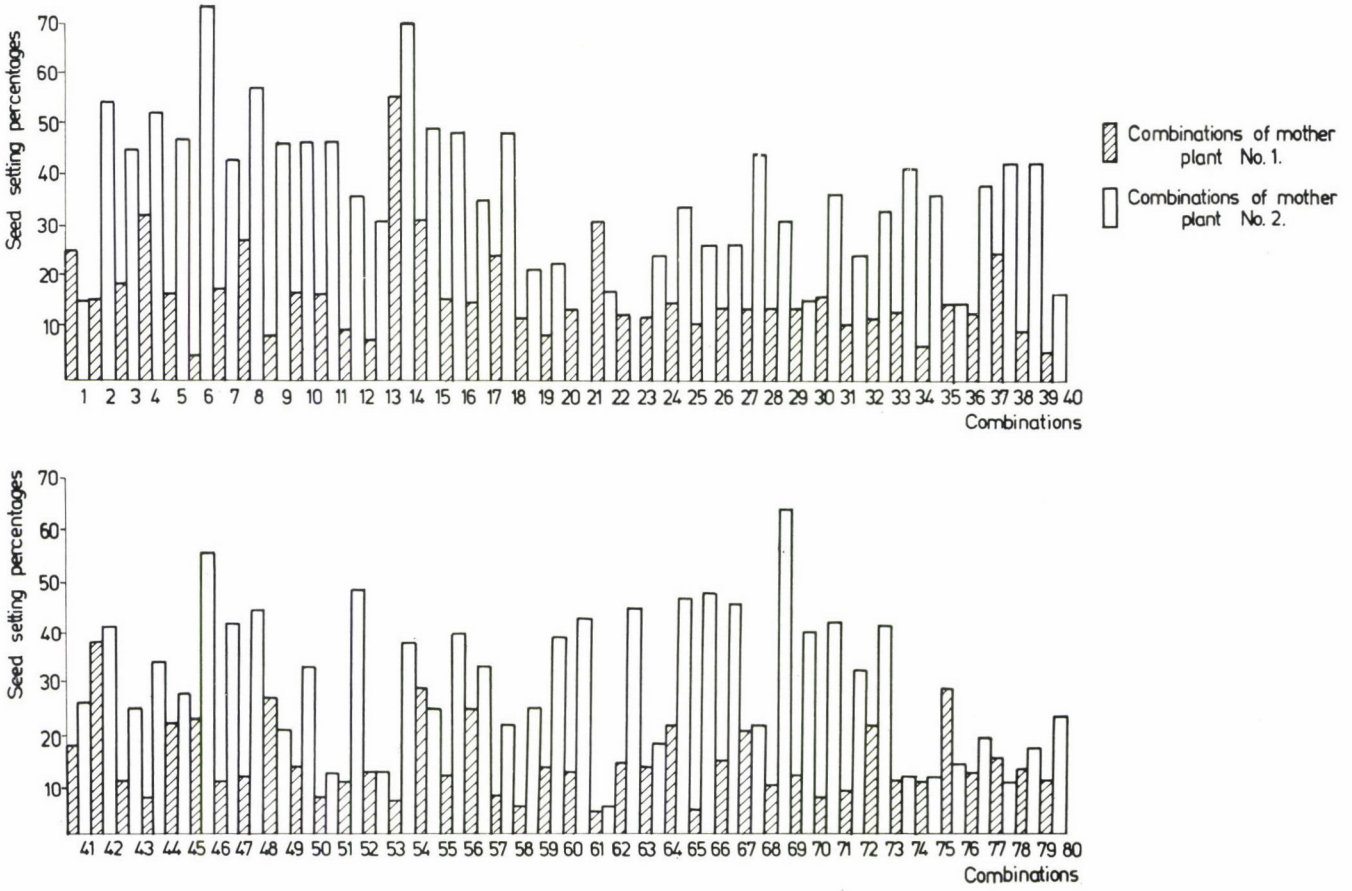

Fig. 4. Seed setting percentages in the F_1 combinations of sterile mother plants No. 1 and No. 2

The above investigations make it possible to choose the best F_1 combinations to form the basic material of hybrid lucerne breeding.

*

Prepared at the Research Institute for Irrigation, Szarvas.

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LEAF AREA AND YIELD COMPONENTS — THEIR RELATIONSHIPS WITH YIELD IN SOYBEAN [GLYCINE MAX (L.) MERR.]

Nodulating (nod) and non-nodulating (nonnod) isolines of soybean [*Glycine max* (L.) Merr.] have been extensively studied (WEBER 1966, HANWAY—WEBER 1971) with respect to their yield and yield components. The nonnod isolines were reported to give more increase in seed yield, dry matter yields, seed size and seed protein due to N fertilization. Recently, HANWAY—WEBER (1971) and EGLI—LEGETT (1973) studied the pattern of dry matter accumulation in some determinate and indeterminate soybeans. BUTTERY *et al.* (1969) characterized the growth rates of some soybeans using the growth equations. Recently, we reported the relative contributions of symbiotic N and fertilizer N for grain production (PAL—SAXENA 1975a) and N nutrition of soybean (PAL—SAXENA 1975b). However, the data on leaf area and yield components of nod and nonnod isolines of specific varieties are rare, particularly under humic subtropical conditions. Therefore, the present study was taken up to determine the effect of fertilizer N on leaf area and yield components (final plant stand, number of pods per plant, number of seeds per pod and 100-seed weight) of the two isolines of Clark and Harosoy under humid subtropical conditions in the foot-hills of the Shivalik range of the Himalya mountains (India). The interaction of symbiosis and fertilizer N is also worth studying with respect to leaf growth and harvest indices in these isolines. Since the symbiotic efficacy of *Rhizobium japonicum* may vary under inoculated and uninoculated conditions, it is of much interest to examine whether symbiosis under these two conditions would have a differential effect on the growth and development of nod soybean. Thus, the objectives of the present investigations were: (1) to study the effect of symbiotic and fertilizer N and their interaction on leaf growth and yield components, (2) to determine the efficacy of symbiotic flora under inoculated conditions in terms of leaf growth and yield components, and (3) to study the inter-relationships among various components and their association with final seed yield.

The nod (inoculated and uninoculated) and nonnod isolines were raised at increasing rates of fertilizer N during three consecutive seasons at the Crop Research Centre. In Kharif (monsoon or rainy season) 1970, only the isolines of Clark were used, whereas in the summer seasons of 1971 and 1972 the isolines of both Clark and Harosoy were used. A single split-plot design with three replications was followed. The isolines were allotted to main plots and N rates to sub-plots. There were five N levels (0, 25, 50, 100, 200 kg N/ha) in 1970, whereas the N rates were increased to six by adding one more level, i.e. 300 kg N/ha, in 1971 and 1972.

The experimental soils were silt loam, high in organic carbon (1.7—2.1%), total N (0.12—0.15%) and available P (32—38 kg/ha), and medium in available K (124—228 kg/ha). The experimental plots for 1970 and 1972 were used for soybean cultivation in the past, whereas those for 1971 had no prior history of soybean cultivation. The crop was uniformly fertilized with 42 kg P/ha and 50 kg K/ha using single super-phosphate and muriate of potash,

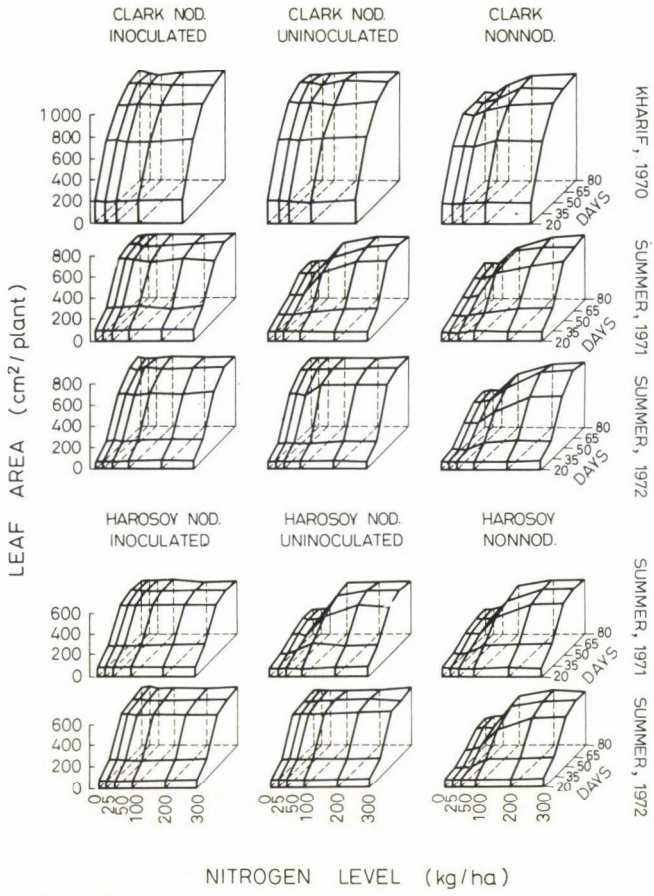

Fig. 1. N fertilization effect on leaf area of nodulating and non-nodulating isolines of Clark and Harosoy soybeans at various stages of growth

respectively, just before planting. The graded doses of N, as per treatment, were side-dressed as ammonium sulphate at the time of planting. The seeds were placed 2—4 cm deep at a distance of 5 cm in furrows spaced 45 cm in 1970 and 30 cm apart in 1971 and 1972.

Leaf Area and Yield Components. Leaf area was measured at 15-day intervals starting from 20 days after planting till 80 days after planting. Leaf area was calculated using a punch technique (WATSON—WATSON 1953). The leaves of the 5 plants were separated and their fresh weights (W) were recorded. The leaves were dropped at random into a tray to form a thick layer and leaf discs were punched out with the help of a cork bore of known radius (r) pressed into the mass at a number of random positions on the tray. In this way, all parts of the leaves had an equal chance of being included in the sub-sample. The fresh weight (w) of all the discs (n) was determined. The total leaf area per five plants (L) was calculated as below:

$$L = \frac{\pi r^2 n \cdot W}{w}.$$

Table 1

Plant population at harvest as affected by different treatments

Treatments	1970	1971	1972
	million/ha		
Isolines:			
Clark nod inoculated	0.288	0.488	0.508
Clark nod uninoculated	0.302	0.525	0.555
Clark nonnod	0.270	0.512	0.498
Harosoy nod inoculated	—	0.555	0.518
Harosoy nod uninoculated	—	0.567	0.516
Harosoy nonnod	—	0.482	0.522
L. S. $D._{0.05}$	n. s.+	0.025*	n. s.
N treatments (kg/ha):			
0	0.289	0.541	0.513
25	0.302	0.544	0.521
50	0.282	0.527	0.528
100	0.283	0.509	0.529
200	0.278	0.509	0.518
300	—	0.497	0.508
L. S. $D._{0.05}$	n. s.	n. s.	n. s.

* Significant at the 5% level of significance.
\+ Non-significant.

Yield components were studied on 5 randomly selected plants at full maturity. The plants were used to obtain data on number of pods/plant, number of seeds/pod, 100-seed weight, and seed yield/plant. Total plants/plot were also counted to calculate final plant stand/ha.

Leaf Area. Leaf area curves with respect to time showed a sigmoid pattern in 1971 and 1972 and a quadratic pattern in 1970 (Fig. 1). The fastest increase in leaf area occurred up to 50 days after planting in all the experiments and it appeared to be almost constant up to the end of the study, i.e. 80 days after planting. Since all the leaves were shed at harvest time, leaf area measurement was not carried out at this time). In general, plants of Clark had a higher leaf area in 1970 than those in 1971 and 1972 (Fig. 1). In addition, the isolines of Clark attained a larger leaf area than those of Harosoy. The interaction between N rates and isolines at various stages of growth (Fig. 1) revealed a negligible effect of N fertilization in the early stages (i.e. 20 days after planting) in all the isolines of both Clark and Harosoy. At later stages, however, the differences due to N application became conspicuous. In the case of inoculated nod isolines of both Clark and Harosoy, N application had no effect on leaf area at any stage of growth. In the case of nonnod isolines, an application of 50 kg N/ha or more caused a conspicuous increase in leaf area over the control. The significant increase in nonnod isolines, however, was observed only up to a level of 100 kg N/ha. With the higher levels of N application (200 or 300 kg N/ha) in nonnod isolines, almost the same final leaf area was achieved as in inoculated nod isolines. Uninoculated nod isolines behaved like nonnod isolines in 1971 and like inoculated nod isolines in 1970 and 1972 (Fig. 1).

Table 2

Number of pods/plant as affected by different treatments

Isolines	N Rates (kg/ha)					
	0	25	50	100	200	300
	pods/plant					
	1970					
Clark nod inoculated	30	37	35	28	38	—
Clark nod uninoculated	25	33	34	37	43	—
Clark nonnod	28	26	30	29	34	—
	1971					
Clark nod inoculated	23	27	29	25	24	27
Clark nod uninoculated	9	10	10	10	24	29
Clark nonnod	10	11	14	22	29	30
Harosoy nod inoculated	19	22	20	19	28	27
Harosoy nod uninoculated	10	10	16	14	29	31
Harosoy nonnod	13	15	17	21	30	32
	1972					
Clark nod inoculated	23	23	25	26	25	24
Clark nod uninoculated	19	20	20	20	19	21
Clark nonnod	15	16	17	17	20	21
Harosoy and inoculated	19	23	25	20	20	21
Harosoy nod uninoculated	17	23	19	23	20	22
Harosoy nonnod	13	15	15	16	18	23

	1970	*1971*	*1972*
L. S. D.$_{0.05}$			
(i) For comparing two N treatment means in the same isoline	n. s.	6.78*	n. s.
(ii) For comparing two isoline means at the same or different N treatments	n. s.	6.79*	n. s.

* Significant at the 5% level of significance.

Final Plant Stand. A population of 0.4 million plants/ha was established in 1970 and 0.6 million plants/ha in 1971 and 1972. A count of the population at maturity revealed that the population decreased in all experiments due to mortality (Table 1). However, the final plant stand was not affected by the various treatments except in the 1971 experiment, where the main effect of the isolines was significant. In this experiment, a significantly higher plant population was observed in the case of uninoculated nod Clark than in inoculated Clark. The nonnod Clark was intermediate, being on a par with that of inoculated nod Clark on the one hand, and with uninoculated nodulating Clark on the other. In the case of Harosoy, however, the nonnod isoline had a significantly lower final plant stand than the nodulating isolines (irrespective of inoculation).

Number of Pods/Plant. Data on number of pods are presented in Table 2. In 1970, the number of pods was not significantly affected by the interaction between N levels and isolines. In 1971, increasing the rate of N application had no effect on pod number in inocu-

Table 3

Number of seeds/pod in different isolines of Clark and Harosoy

Isolines	1971	1972	1973
	seeds/pod		
Clark nod inoculated	2.96	2.50	2.81
Clark nod uninoculated	2.80	2.60	2.83
Clark nonnod	2.75	2.50	2.71
Harosoy nod inoculated	—	2.50	2.62
Harosoy nod uninoculated	—	2.30	2.53
Harosoy nonnod	—	2.50	2.62
L. S. $D_{0.05}$	0.11*	n. s.	0.16*

* Significant at the 5% level of significance.

lated nod isolines, whereas in the case of uninoculated nod and nonnod isolines, N fertilization caused a very conspicuous and significant increase in pod number when the N rate was 200 kg/ha or more. In the case of Harosoy, on the other hand, the increase in pod number due to N application at 200 kg/ha or more resulted in a significant increase in all the isolines, although the magnitude of the increase was less in inoculated nod isolines than in uninoculated nod and nonnod isolines. For instance, the maximum increases over the control due to N fertilization were 49%, 194% and 146% in inoculated nod, uninoculated nod and nonnod Harosoy, respectively. In 1972, similar to the 1970 experiment, the interaction between N rates and isolines was non-significant. However, the increase in pod number of nonnod plants due to N fertilization was more pronounced than that of nod plants. The nonnod isolines of Clark and Harosoy showed an increase in pod number of 45% and 75% respectively over the control when supplied with 300 kg N/ha, as compared to only 6—10% and 10—41% in the case of their respective nodulating counterparts.

Number of Seeds/Pod. Seed number/pod was not much affected by the various treatments. Statistical analysis of the data revealed that differences between the isolines were significant in 1970 and 1972 (Table 3). In 1970, the seed number of inoculated nod Clark was significantly higher than that of uninoculated nod and nonnod Clark. In the 1972 experiment, such effects were not observed. Isoline effects, in 1972, proved to be significant because the number of seeds in the Harosoy background was smaller than that in the Clark background.

100-Seed Weight. This component was significantly affected by the interaction between N rates and isolines in all the experiments. In general, inoculated nod isolines produced bolder seeds than nonnod isolines. N fertilization had no effect on the 100-seed weight of nod isolines of Clark and Harosoy except on uninoculated ones in 1971 which behaved similarly to nonnod isolines. The nonnod isolines responded to N fertilization with an increase in 100-seed weight. This effect of N fertilization in nonnod isolines became more apparent when 100 kg N/ha or more was applied. In the 1970 experiment, an application of 200 kg N/ha caused an increase in seed weight of about 19% over the control. In 1971, the increases in seed size over the control due to 300 kg N/ha were 31% and 42% in uninoculated nod and nonnod Clark and 31 and 43% in uninoculated nod and nonnod Harosoy, respectively. Similarly, in 1972, increases of 26% and 27% over the control were obtained by 300 kg N/ha nonnod Clark and Harosoy, respectively.

Table 4

100-seed weight as affected by different treatments

Isolines	N Rates (kg/ha)					
	0	25	50	100	200	300
	g/100 seeds					
	1970					
Clark nod inoculated	18.2	17.0	18.3	17.9	18.0	—
Clark nod uninoculated	19.0	18.5	18.5	18.3	17.7	—
Clark nonnod	12.8	13.6	13.5	15.9	16.5	—
	1971					
Clark nod inoculated	20.0	19.2	19.2	20.3	19.9	19.2
Clark nod uninoculated	14.0	14.4	15.0	14.7	15.4	18.3
Clark nonnod	12.8	13.3	14.0	14.7	15.2	17.3
Harosoy nod inoculated	16.8	18.5	18.0	19.7	19.6	18.7
Harosoy nod uninoculated	15.9	16.1	17.6	18.9	18.3	18.3
Harosoy nonnod	12.9	13.8	14.6	15.7	19.3	18.6
	1972					
Clark nod inoculated	19.5	18.4	18.2	19.5	19.4	18.6
Clark nod uninoculated	18.4	18.2	18.7	18.8	18.5	18.3
Clark nonnod	13.2	13.7	14.2	14.5	16.1	16.6
Harosoy nod inoculated	17.6	16.6	17.8	17.1	17.1	17.0
Harosoy nod uninoculated	17.3	17.4	17.4	17.2	17.3	16.9
Harosoy nonnod	13.1	14.2	14.8	15.8	16.4	16.8

L. S. D.$_{0.05}$	*1970*	*1971*	*1972*
(i) For comparing two N treatment means in the same isoline	1.48**	2.29*	2.43*
(ii) For comparing two isoline means at the same or different N treatments	1.44**	2.53*	2.70*

* and ** significant at the 5% and 1% level of significance, respectively.

In general, N fertilization did not appear to be helpful in increasing the leaf area, pod number and 100-seed weight of inoculated nod isolines. Effective nodulation and symbiotic N fixation (PAL—SAXENA 1975b) are essentially the reasons for this type of behaviour. Although the contribution of symbiosis decreased (83% to 12%), accompanied by the increasing contribution of inorganic N (17% to 88%), owing to increasing rates of fertilizer N, the gain in leaf are and yield components remained negligible in inoculated nod isolines. This was also true with the seed yield data (PAL—SAXENA 1975a). In contrast to this, non-nodulating isolines responded to N fertilization with an increase in the leaf area, pod number and 100-seed weight. However, even at the highest level of N fertilization in nonnod isolines, none of the components were higher compared to those in inoculated nod isolines. This negates the possibility of increasing the soybean yield through fertilizer N supply. In 1971 uninoculated nodulating isolines responded to N fertilization. This is due to the fact that the soil of 1971 was quite virgin for soybean cultivation and no nodulation occurred (PAL—SAXENA

Table 5

Correlation coefficients between various growth and yield components. Data for nodulating as well as non-nodulating isolines of both cultivars were used together for computing r

Components	Leaf area+	Number of pods/plant	100-Seed weight	Seed	
				yield/plant	yield/ha
1970	*1971 and 1972*				
Leaf area		0.792** (0.706**)	0.699** (0.898**)	0.811** (0.859**)	0.775** (0.958**)
Number of pods/plant	0.553**		0.689** (0.782**)	0.895** (0.877**)	0.648** (0.753**)
100-seed weight	0.948**	0.386		0.825** (0.873**)	0.914** (0.870**)
Seed yield/plant	0.848**	0.648**	0.804**		0.796** (0.887**)
Seed yield/ha	0.961**	0.460*	0.778**	0.848**	

Values in parentheses correspond to 1972.
* and ** significant at the 5% and 1% levels, respectively.
+ Leaf area at 65 days after planting (pod filling stage).

1975a). This would also suggest that in the 1971 experimental plots, either native symbiotic flora (*Rhizobium* sp.) were absent or if they were present, they must have been at most of the cowpea group. On the other hand, the responses of uninoculated nod isolines to N fertilization in 1970 and 1972 were negligible. This is due to the fact that the soils for the 1970 and 1972 experiments had been used for soybean cultivation, which resulted in as much effective nodulation as was obtained in inoculated conditions. This statement is very well supported by data on nodulation and symbiotic N fixation (PAL—SAXENA 1975b).

It is, therefore, deduced that under the humic subtropical conditions in the foot-hills (tarai) of the Himalayas, inoculation alone could result in better growth and development in soybean. Furthermore, soybean could be grown, even without inoculation, on soils that have been used for soybean cultivation in the past and are rich in organic matter. In the absence of nodulation, an application of about 200 kg N/ha or more would be sufficient to obtain better growth and development of soybean.

Correlation Studies. Although seeds yield/ha (PAL—SAXENA 1975a) and seed yield/plant (PAL—SAXENA 1976) have been discussed elsewhere, these are also included for correlation studies. Correlation coefficients for each of the relationships are given in Table 5. (Since final plant stand and number of seed/plant did not exhibit significant relationships with any of the other parameters, *r* values for their relationships are not given.) Table 5 shows that the leaf area (at 65 days after planting), number of pods/plant and 100-seed weight are positively related with each other, and this concurrently affects the yield/plant and yield/ha. Leaf area exhibited a high order of relationship (significant at < 0.01) with pod/plant, 100-seed weight, yield/plant and yield/ha. This suggests that during the pod-filling stage, a leaf area of about 1000 cm^2/plant in the rainy season (July—October grown crop) and about 600 cm^2/plant in the summer season (March—June grown crop) would result in higher soybean production. Similarly, pod number/plant and 100-seed weight were also highly significantly correlated with seed yield, though a non-significant correlation existed between pod number and 100

grain weight in 1970. Yield/plant may explain the 61—77% variation in yield/ha, which indicates that yield/plant alone may not be enough to predict the soybean production/ha, but final plant stand is also of prime importance. Although r values with final plant stand were not significant, it could explain the rest of the variations in yield/ha.

*

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LECTIONES

SECONDARY SALINIZATION AND ALKALIZATION OF SOILS IN IRRIGATED AREAS*

Irrigation exerts a great influence on the upper layers of the earth's crust, not only by altering the weathering processes and the transport of their products in these layers, but by affecting practically every element of the natural environment. The irrigation results in a rapid and essential transformation of the earth's surface, particularly in the top layers of the soil.

As regards the purpose of irrigation, it is exclusively connected with crop production. Our ultimate aim is to increase agricultural production by insuring continuously and regularly the optimum water supply for the plants.

The execution of this aim poses very complex problems which can be solved successfully only if the totality and the interaction of agronomical, culture-technical and soil science factors are taken into careful consideration.

The ability of plants to take up and to utilize the applied irrigation water is profoundly influenced by the soil properties. At the same time irrigation water has an important effect on the physical, chemical and biological processes taking place in the soil. As a result of irrigation the water regime of the soil changes and this may permanently or temporarily alter the various soil properties.

Among the diverse effects of irrigation on soils, particular attention should be paid to secondary salinization and/or alkalization and water-logging processes. Those soils, which are saine or alkali affected by irrigation are generally called secondary salinized and/or alkalized soils. All areas where this hazard may arise can be indicated as potentially salt affected territories.

Theoretically, there are many factors affecting salt affected soils, however, practically it is irrigation which leads to the formation of many million hectares of saline and/or alkali soils in different parts of the world. Often paradox things happen in irrigation systems established by thorough work and expensive planning and construction, when the soils, instead of increasing in their fertility, transform into poor saline land. This process is known as secondary salinization and/or alkalization, and is as old as irrigated agriculture.

Many thousands of square kilometres of fertile irrigated lands were transformed into saline and alkali deserts during the history of mankind under the influence of improper irrigation. Unfortunately, this is not a thing of the past. The secondary salinization and/or alkalization process is showing a disastrous increase, parallel with the construction of new irrigation systems in many countries all over the world, particularly in arid and semi-arid regions, of in regions with mineralized groundwaters near the surface of the soil.

* Lecture held at the Vth Congress of the Yugoslav Society of Soil Science (Sarajevo. 31 May—2 June, 1976).

The extension of irrigation — according to the demand for the increase of food production — makes it imperative to pay due attention to potential salinization and/or alkalization in order to study and characterize this process, as well as to predict and prevent it wherever possible.

It is well known that the majority of the irrigated territories of the world are exposed to the hazard of secondary salinization, alkalization and water-logging.

According to estimations made by the UN and affiliated organizations (FAO, UNESCO) more than 50% of all irrigated lands of the world have been damaged by secondary salinization and/or alkalization and water-logging. According to the same estimations, many million hectares involved in irrigation systems have to be abandoned from production yearly as a consequence of the above mentioned processes (ANONYMOUS 1973).

While the existing salt affected soils can be recognized on the basis of a few morphological, chemical and physico-chemical observations and determinations, the recognition of the long-term hazard of salinity or alkalinity on any given territory necessitates special surveys and methods.

In the light of the paramount importance of irrigation and of the close relationship existing between irrigation, drainage and the salinity and/or alkalinity of soils, it was deemed necessary to delineate — whenever possible on the basis of the available data — those areas on the maps of salt affected soils which are exposed to the hazard of salinity and alkalinity owing to the introduction, the present practice and/or to the further extension of irrigation.

Fig. 1 presents a map indicating the present and potential salt affected soils in Europe.

The Map of Salt Affected Soils in Europe (sponsored by UNESCO, FAO and ISSS) shows the areas where potential salt affected soils are developing (ANONYMOUS 1974). This map demonstrates that even in Europe — where the extension of salt affected soils is lower than in some other continents — the surface covered by potential salt affected soils is equal to or greater than the territories where present salt affected soils occur. Evidently, in continents with more arid conditions, this rate is much higher.

Secondary salinization and alkalization processes may take place mainly in one or more of the following situations:

1. Accumulation of salts from irrigation water of poor quality.

2. Increase in the level of groundwater. *a)* The salt content of the groundwater accumulates in the deeper soil layers; *b)* the rising groundwater transports the salts from the deeper soil layers to the surface or surface layers, or *c)* the rising water table limits natural drainage and hinders the leaching of salts.

3. Lack or low effectivity of drainage systems in irrigated soils.

The possible hazard of salinization and/or alkalization in irrigated areas or areas to be irrigated may be determined by the following factors:

1. Climatic factors such as: temperature, rainfall, humidity, vapour pressure, evaporation and their fluctuations and dynamics;

2. Geological, geomorphological, geochemical, hydrological, hydrogeological and hydrochemical factors such as: natural drainage, the depth and fluctuation of the water table, the direction and velocity of horizontal groundwater flow, salt content and composition of the groundwater, etc.

3. Soil factors such as: soil profile, texture, structure, saturated and unsaturated water conductivity, soluble salt content, salt composition and salt profiles, exchangeable cations, pH, etc.

4. Agrotechnics such as: land use, crops, cultivation methods, etc.

5. Irrigation practices such as: the amount of irrigation water: method, frequency and intensity of irrigation, salt content and composition of irrigation water, natural and artificial drainage, etc.

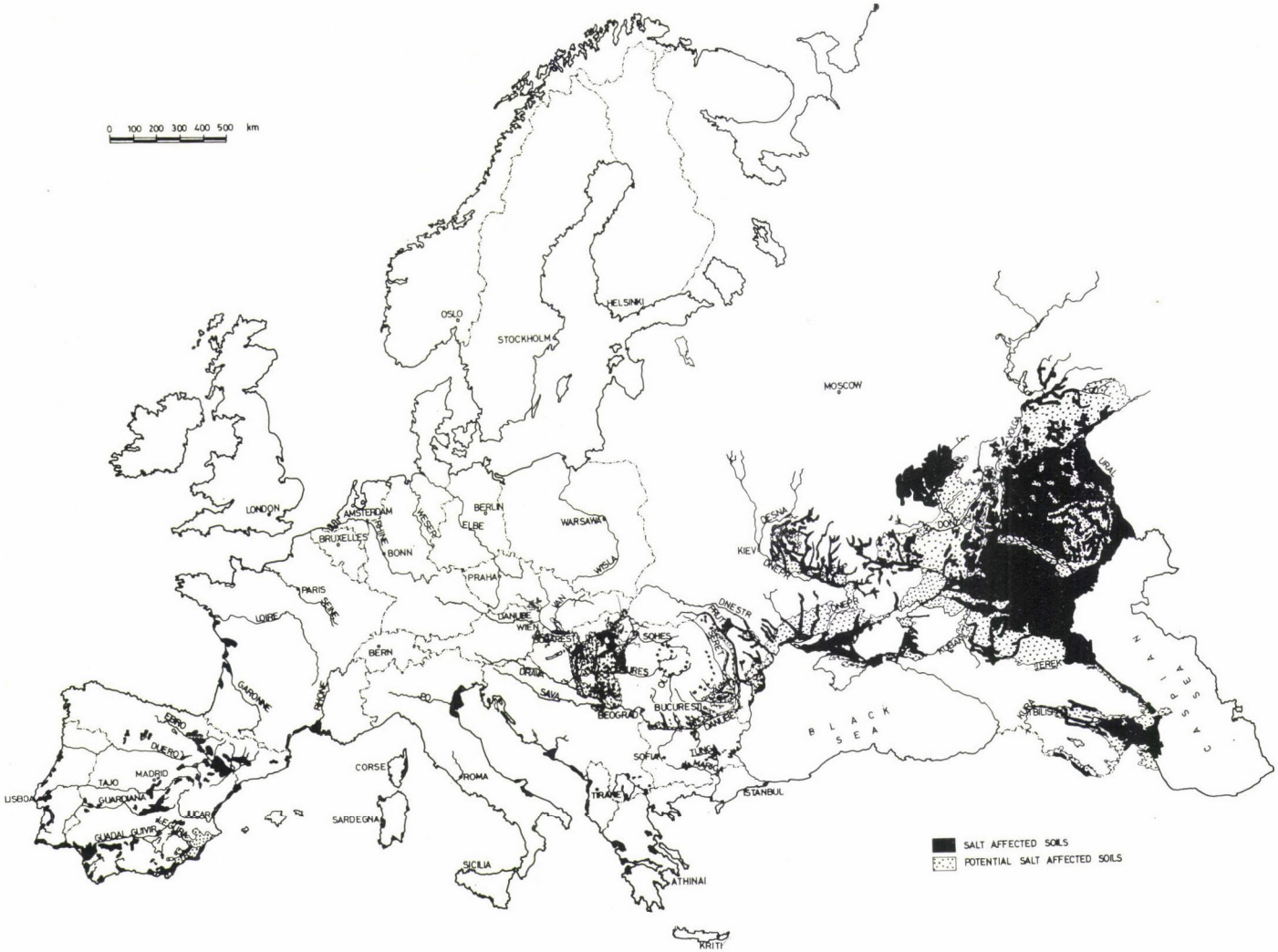

Fig. 1. Extension of salt affected soils in Europe

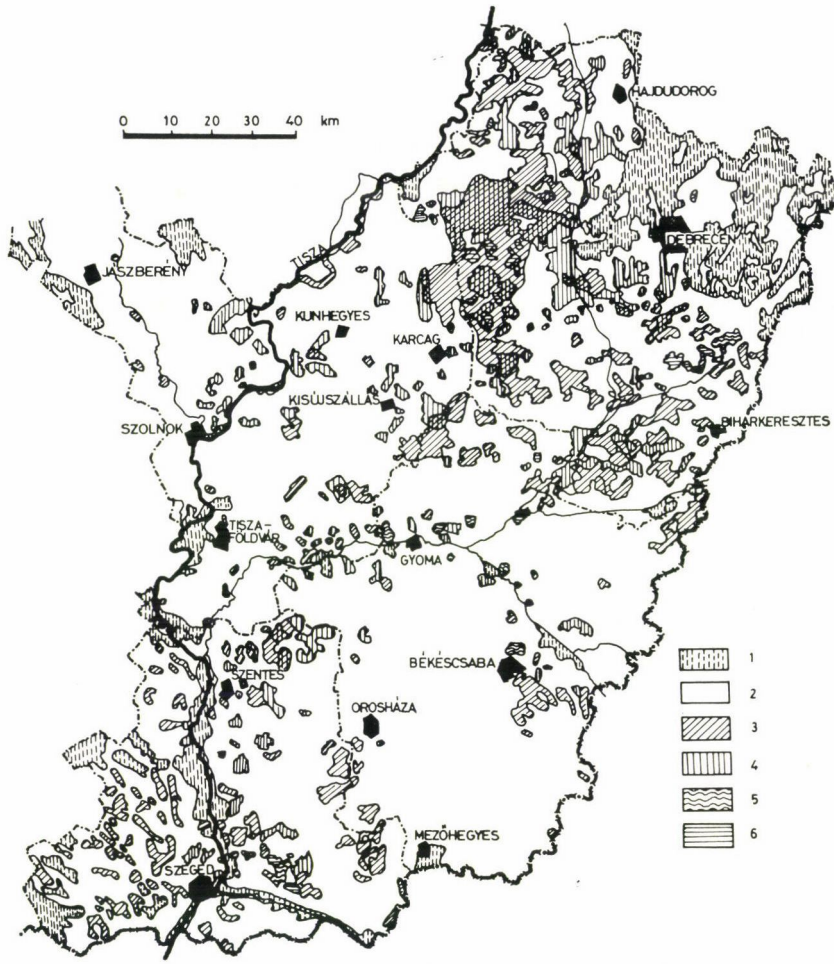

Fig. 2. General possibilities of effective irrigation from the viewpoint of soil conditions and the existing undesirable soil processes due to irrigation in the Eastern part of the Hungarian Plain (1. Areas to be irrigated, 2. Areas that may be irrigated conditionally, 3. Areas not to be irrigated, 4. Secondary salinization and alkalization, 5. Secondary peat formation, 6. Secondary salinization and alkalization combined with secondary peat formation)

The above-mentioned factors determine the aims and methods of the preliminary survey of soils in order to define the degree or the existence of potential salinity and/or alkalinity (ANONYMOUS 1971).

Evidently, the environmental conditions on the one hand and the methods of utilizing the territory in question on the other hand should be taken into consideration when an area is evaluated in this respect. Due to this fact different limit values and different methods — based on uniform principles — should be selected in the course of this procedure. For example, in arid regions, in deserts and semi-deserts practically all irrigated areas are potentially salt affected owing to the arid climate as well as to the high accumulation of salts in the soils and waters.

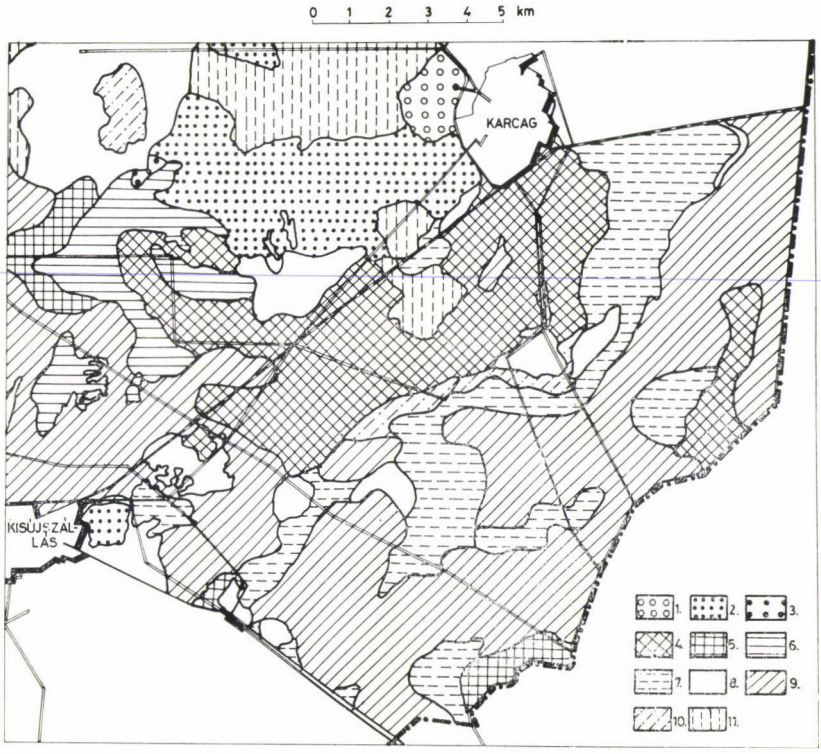

Fig. 3. Soil Map (1. Non-calcareous meadow chernozem soil, 2. Calcareous meadow chernozem soil, 3. Meadow chernozem soil, solonetzic in deeper layers, 4. Shallow meadow solonetz soil, 5. Medium meadow solonetz soil, 6. Deep meadow solonetz soil, 7. Solonetzic meadow soil, 8. Strongly solonetzic meadow soil, 9. Meadow soil, 10. Meadow soil, salty in deeper layers, 11. Calcareous chernozem meadow soil)

The basic aims of the survey and study of potentially saline or alkaline soils are to predict the harmful processes and to elaborate, whenever possible, methods suitable for preventing the occurrence of secondary salinization and alkalization.

In order to develop a reliable method of predicting salinization and alkalization the following problems have to be solved:

1. The main sources of water soluble salts (irrigation water, groundwater, surface waters, salty deep soil layers, etc.) must be identified.

2. The main features of the salt regime must be characterized (salt balances); and the whole range of natural factors influencing the salt regime must be analysed.

3. The effect of irrigation and drainage on the water and salt regimes of the soil must be predicted and determined.

Consequently, an exact salinity and/or alkalinity prognosis must be based on an evaluation of many natural and human factors and a knowledge of the existing soil processes, as well as the pattern of planned soil utilization (DARAB 1962).

In the Hungarian Plain, the processes of secondary salinization and alkalization are wide-spread and show a tendency to increase, parallel with the setting up of new irrigation systems, primarily in the Danube and Tisza river valleys. The problem became urgent with the establishment of new power plants and new irrigation systems attached to them.

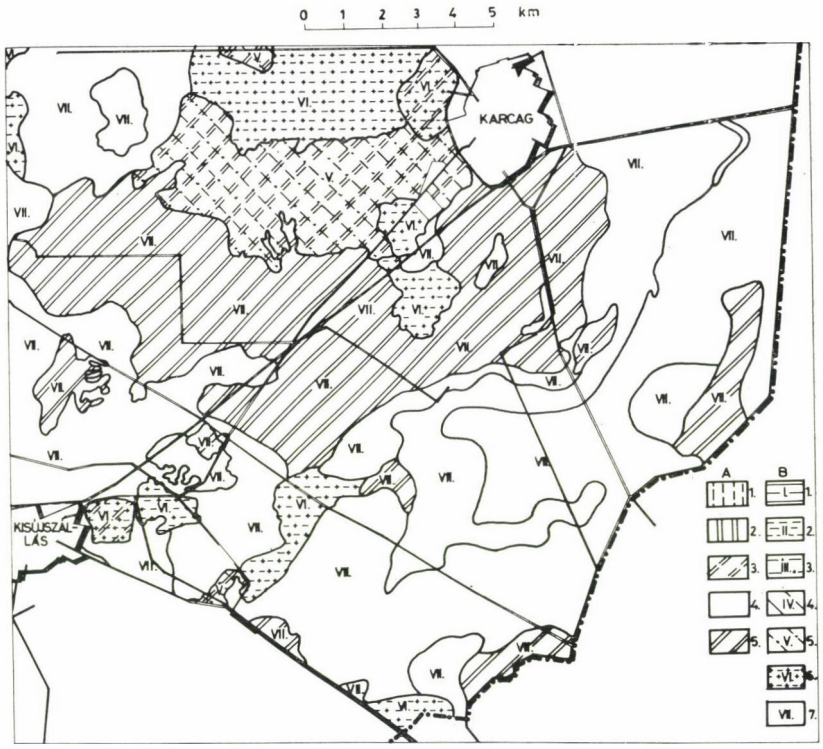

Fig. 4. Map of the mechanical composition of the soils and of the water regime properties, A (Mechanical composition: 1. sand; sandy loam, 2. loam, 3. clay loam, 4. clay, 5. heavy clay), B (Water regime properties: 1. Soils with very low water holding capacity and very high permeability, 2. Soils with low water holding capacity and very high permeability, 3. Soils with medium water holding capacity and high permeability, 4. Soils with high water holding capacity, a high available moisture content and medium permeability, 5. Soils with high water holding capacity, a high available moisture content and medium permeability, 6. Soils with very high water holding capacity and low permeability, 7. Soils with very high water holding capacity and very low permeability

In order to predict and prevent the hazard of the above mentioned processes, a thorough survey has been carried out regarding all soils to be irrigated, in order to estimate and determine the probable hazard of salinization and/or alkalization, and recommendations have been made. The details of this survey have been published (SZABOLCS *et al.* 1969).

I. Reconnaissance survey on the scale of 1 : 100 000

The map presented in Fig. 2 was constructed on a scale of 1 : 100 000 and indicates the general possibilities of an efficient salinity-alkalinity control, of the prevention of secondary salinization and alkalization processes, and the preconditions of effective irrigation from the viewpoint of soil conditions. For the construction of this synthesis map a series of maps were prepared or adopted using the same scale:

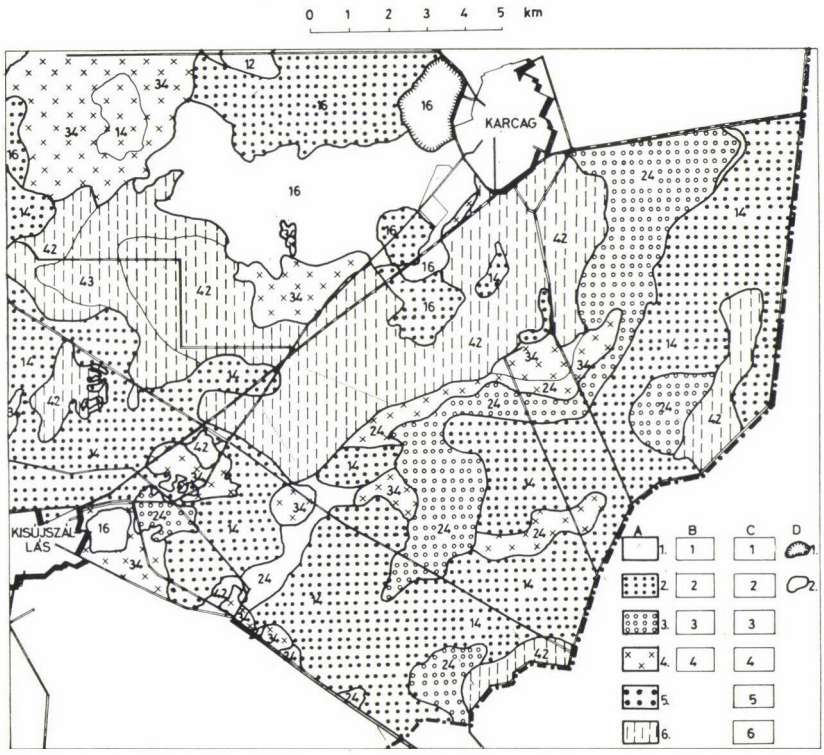

Fig. 5. Map of the water soluble salt and exchangeable Na^+ content of the soils, A (The average total salt content of the soils above the ground water as a percentage. 1. 0.050—0.075%, 2. 0.075—0.10%, 3. 0.10—0.13%, 4. 0.15—0.20%, 5. More than 0.20%); B [The maximum salt content of the salt profile as a percentage. (The first figure of the two-figure number in the fields indicates): 1. Less than 0.10%, 2. 0.10—0.20%, 3. 0.20—0.40%, 4. More than 0.40%]; C [Depth of appearance of the salt maximum in cm. (The second figure in the two-figure number in the fields indicates): 1. 0—5 cm, 2. 5—25 cm, 3. 25—50 cm, 4. 50—100 cm, 5. 100—150 cm, 6. More than 150 cm]; D (The pH value of the B_1 horizon. 1. 8, 2. 8—9)

— soil map (soil type)
— map of the average depth of the water table
— map of the minimum depth of the water table
— map of the average salt concentration in the groundwater
— map of the chemical composition of the groundwater.

The following information was also used:

— map of the absolute height of the water table
— map of the hydrophysical properties of the soils
— geological maps
— data of long-term groundwater-table observations (more than 500 wells were observed for over ten years).

On this map the following categories were distinguished:

a) Areas to be irrigated;

b) Areas that may be irrigated conditionally;

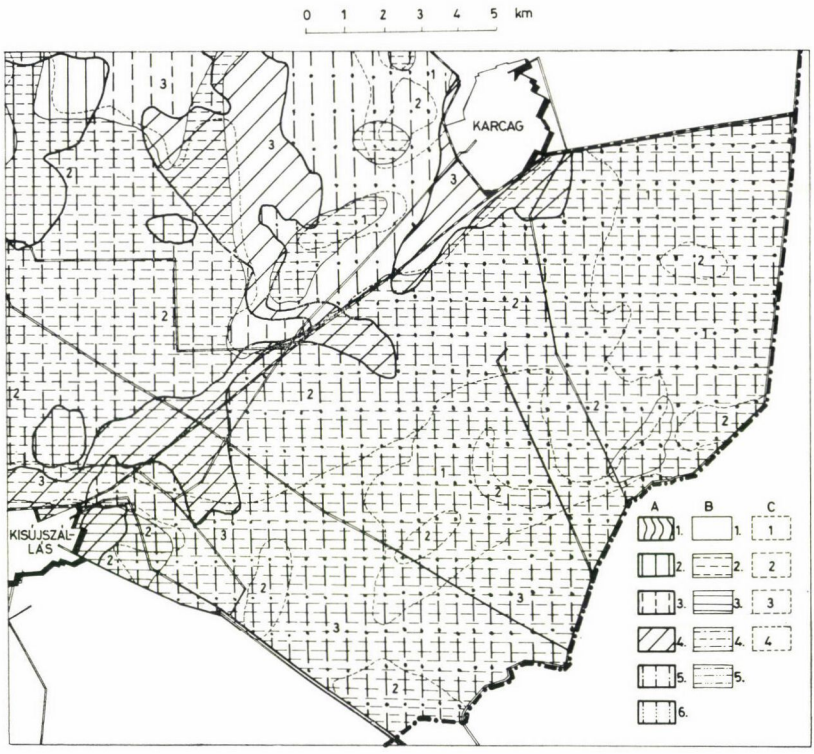

Fig. 6. Ground water map, A (The average depth of the water table in metres. 1. 0—15, 2. 1.5—2.5, 3. 2.5—3.5, 4. 3.5—4.5, 5, 4.5—6.0, 6. >6.0); B (Total salt content of the ground water in g/l. 1. 0—1, 2. 1—2, 3. 2—4, 4. 4—8, 5. >8); C (Na % in the ground water. 1. <50% 2. 50—75%, 3. 75—90%, 4. >90%)

c) Areas not to be irrigated;
d) Secondary salinization and alkalization;
e) Secondary peat formation;
f) Secondary salinization and alkalization combined with secondary peat formation.

II. Detailed soil and hydrologic surveys and mapping

After having gained a general knowledge of factors and processes influencing the present and future salinity-alkalinity status of soils over a large area (water catchment area, ecological region, irrigation massive, etc.) more detailed soil and hydrologic surveys are necessary for the more detailed description and prediction of salinization-alkalization and reverse processes, and for the more exact and accurate analysis of factors which influence them and of the possibilities of control. The elements and subjects of the detailed surveys are the same or similar to those of the reconnaissance survey. But, on account of the larger scale, more sub-factors have to be surveyed, measured, monitored and analysed more thoroughly (DARAB—FERENCZ 1969).

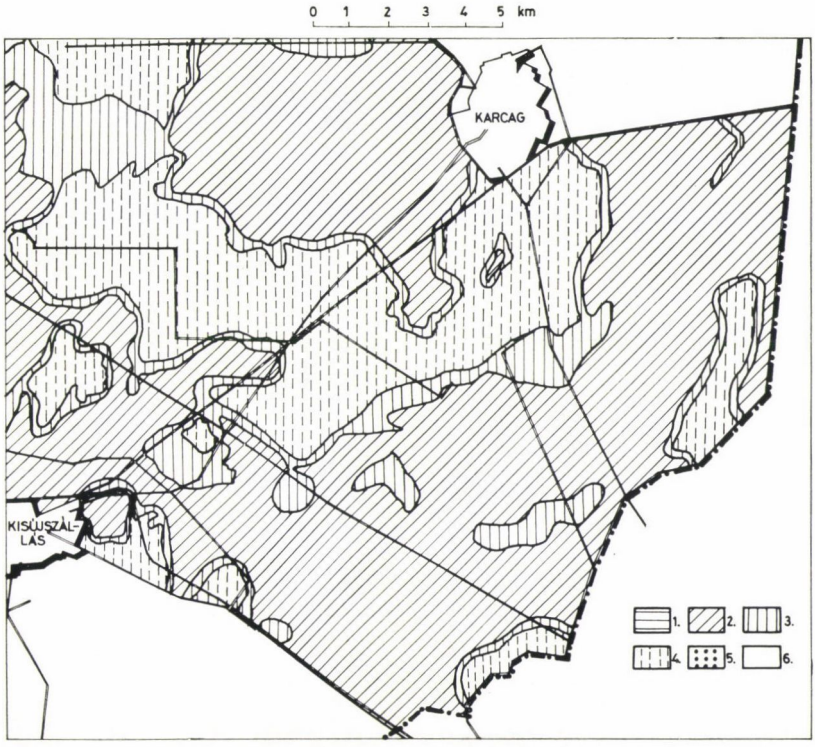

Fig. 7. Map indicating the critical depth of the water table (Critical depth of the water table: 1. 2 m, 2. 2.5 m, 3. 3 m, 4. 3.5 m, 5. 4 m, 6. 4.5 m)

A) Soil characteristics

1. Characteristics of the soil cover (soil types, subtypes, variants and their associations; structure of soil cover; heterogeneity; evaluation of the existing and potential soil processes; etc.).

2. Characteristics of the parent material (evaluation of parent material as a potential salt source and as the main influencing factor of the vertical and horizontal flow of subsurface waters).

3. Physical characteristics of the soil (texture structure: rate and stability of aggregation, porosity, pore-size distribution; moisture characteristics of the soil: pF-curves, water retention, water holding capacity, wilting percentage, available moisture range; saturated flow; flow of solutes in unsaturated soil layers; time and spatial variation of suction and/or moisture profiles). These factors have to be interpreted first of all for the description and prediction of water and salt movement in layered soil profiles: the possibilities and preconditions of leaching on the one hand and those of salt accumulation from the groundwater on the other hand.

4. Salt regime characteristics of the soil and of the area (spatial — vertical and horizontal — and time variations of the quantity and quality of water soluble salts: general and factorial salt balances).

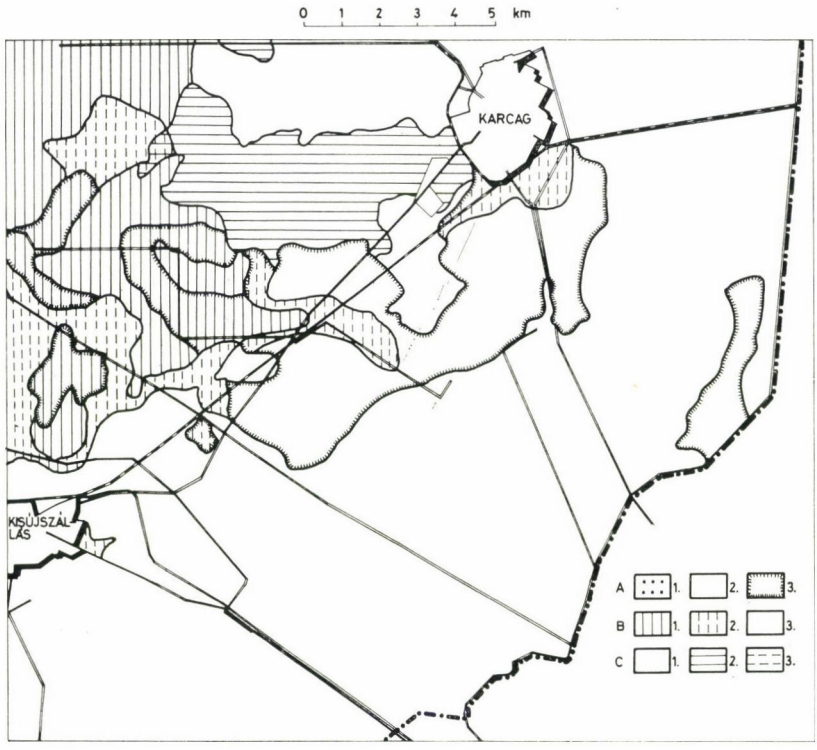

Fig. 8. Map indicating the conditions and the possibilities of irrigation, A (The possibilities of irrigation. 1. Areas where irrigation is suggested, 2. Areas where irrigation is suggested conditionally, 3. Areas where irrigation is not suggested); B (The conditions of irrigation. 1. Lowering of the water table, 2. The rise of the water table must be prevented, 3. The regular control of the water table is necessary); C [General directives of irrigation. 1. Frequent irrigation with low water dosage rates, 2. Medium frequent irrigation with medium water dosage rates, 3. One (or infrequent) irrigation with high water dosage rates]

5. Other chemical characteristics of the soil (soil reaction; carbonate-status; CEC; exchangeable cations, especially the mobile sodium balance; etc.). In this respect special attention has to be paid to the reversibility of salinization-alkalization processes, because reversible processes can be controlled and balanced relatively easily while the salinity-alkalinity control meets serious difficulties in the case of irreversible (or near irreversible) processes (i.e. salinization and alkalization of heavy-textured swelling clays under the effect of sodium salts capable of alkaline hydrolysis: Na_2CO_3, $NaHCO_3$).

B) Hydrological characteristics

6. Groundwater hydrology (depth and fluctuation of the water table; horizontal flow of the groundwater as a function of hydraulic gradient and hydraulic conductivity; main factors of groundwater supply; etc.).

7. Chemical characteristics of the groundwater (concentration and ion-composition of the groundwater; changes in these factors during the upward capillary flow, etc.).

Factors 5 and 7 supply information for the estimation of the possibilities of salt accumulation processes from the groundwater (reality of the hazard of secondary salinization and alkalization due to a rise of the water table under the effect of changing environmental factors or human activity) and for the evaluation of subsurface waters as potential irrigation waters.

8. Surface water characteristics (listed in the preliminary survey). These factors have to be evaluated as a potential salt source and as a potential water source for irrigation and leaching.

Adequate data on the above mentioned soil and hydrological characteristics

— can be obtained from reports on geographical, geomorphological, hydrological, hydrogeological and ecological surveys (descriptions, data, maps, cartograms, various air photos, photomosaics, and recently satellite spectral photographs, etc.);

— can be collected from the regular climatological, groundwater and piezometric observations and available soil moisture records;

— can be measured directly during the detailed soil and hydrologic surveys;

— can be calculated and/or estimated from available data or from measured values.

Based on the above mentioned principles, a series of maps has been prepared, originally on a scale of 1 : 25 000, for the whole area in order to help not only the prediction and prevention of secondary salinization and alkalization, but also the praxis of irrigation, related to the quantity and quality of irrigation water, type of irrigation, etc.

In Figs 3, 4, 5, 6, 7 and 8 the maps indicate all important soil and environmental properties (i.e. salinization and alkalization of ground and water; most important physical and chemical soil properties; "critical" depth of the groundwater, etc.) which should be taken into consideration during both the construction and exploitation of irrigation systems.

In Hungary this detailed mapping has been carried out jointly by the Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences and the Hungarian National Institute for Agricultural Quality Testing, Budapest, for the whole territory where irrigation is envisaged for the future.

III. Monitoring

A detailed, follow-up survey system is necessary to regularly measure water and soil processes during the operation of the irrigation project — even though planning may have been perfect and as much caution as possible taken to prevent soil damage. The survey system should indicate the measures that must be taken to control the water and salt regimes.

Even with severe precautionary measures, it might happen that one or more factors unexpectedly exceeds its limit. In this case the preconditions of effective irrigation would not prevail and harmful soil processes might occur and depress soil fertility. For example, even the forecasted depth of the water table and the predicted salt balances based on a detailed and complex analytical study cannot give an exact, certain forecast of the integrated effects of natural factors (climatic, hydrological, hydrogeological, etc.) and irrigation, especially for the whole area of the irrigation project (irrigation massive) during long periods.

Thus an adequate water and salinity control system is necessary in which the following factors have to be outlined and thoroughly determined:

— aim and subject of investigations (the factors and features to be examined),

— sampling (time, frequency, intervals, methods, etc.),

— field and laboratory examinations (including procedures, statistical analysis, possibly a computer programme, etc.),

— necessary measures must be taken, on the basis of the evaluated results, for water

and salinity control. These measures should prevent harmful effects of irrigation such as: peat formation, salinization, alkalization, solodization, etc.

In respect of the world-wide importance of salinization and alkalization problems of irrigation systems, the described — or similar — methods should be studied and elaborated in all cases of projecting and establishing irrigation systems in all areas where these processef may develop or strengthen if affected by extended irrigation.

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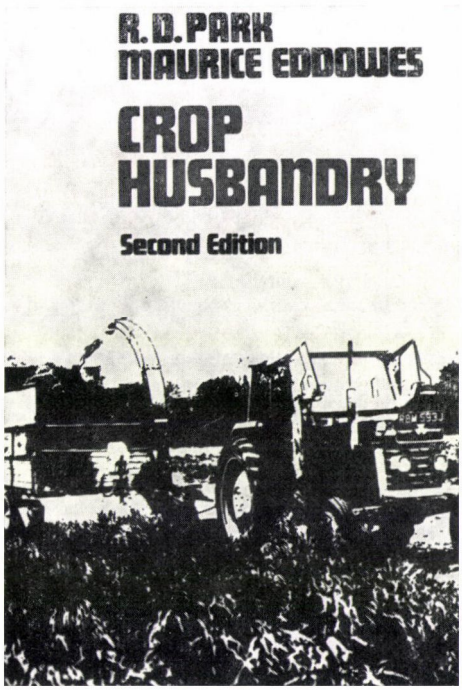
RECENSIONES

PARK, R. D.—EDDOWES, M.: *Crop husbandry*. 1975. Oxford, Univ. Press. Second Ed.



The authors summarize the fundamental and most important facts of crop production on 323 pages divided, for the sake of clarity, into sections and complete with 24 figures, 22 tables and an index. The book is intended primarily for practical workers.

Part I presents statistical data on crop growing in Great Britain and the European Economic Community, and gives a detailed evaluation of the sowing areas and yield averages during the last decades in relation with the level of mechanization, the rate of fertilization and the optimization of work. The economic efficiency of production is evaluated under the production conditions prevailing in the United Kingdom.

Part II qualifies the most important factors that influence the yield. The effect of soil and climate on production, which also determines the cultivation methods, is discussed with full particulars in the handbook. The authors describe the major soil types, their structures and water regime, in particular the removal of ground water by drainage, and irrigation. Besides methods of irrigation the optima of irrigation water for soil types and crops are also given. Besides the classical types of crop rotation the inclusion of monocultures resulting from herbicide application in crop rotation is also discussed in addition to a number of perennial crops. Grassland management — a highly important branch of agriculture in the United Kingdom — can similarly be included in crop rotation as a perennial crop. Sowing is described — together with the soil cultivation machines — in connection with the proper method of seed-bed preparation, with special regard to mechanical weed killing. The practice of plant protection is discussed together with the application os pesticides (herbicides fungicides, insecticides), but the fullest details are given for herbicides: phenoxy-acids, triazins, urea derivatives, bipyridyls, substituted phenols, carbamates, and other herbicides, e.g. triazols. The authors suggest

growing phytopathologically resistant varieties in the first place, but also give an account of the practical advantages of using systemic fungicides. They speak of soil sterilization and the possible chemicals for use against phytopathogenic fungi, bacteria and viruses together with methods of control. They summarize the major pests of field crops and how to control them from a practical point of view. In particular the effects of insecticides jointly applied with fertilizers are introduced.

Part III deals with the practice of crop production, with special regard to the supply of nutrients, including both macro- and micro-elements. Nitrogen application substantially increases the chlorophyll content and also influences the quantity of yield and the protein content. The effect of phosphorus application, though not spectacular, is certainly felt in the yield increase. The levels of phosphates soluble in water and 2% citric acid are regarded as being of basic importance from the point of view of nutrient supply and availability, though great importance is also attached to the insoluble and total phosphate contents, with a view to their potential transformation. In the authors' opinion potassium fertilization by itself or in combination with nitrogen and phosphorus is principally involved in improving the quality of the yield, and does not cause yield surpluses. Of the micro-elements the advantages of calcium, magnesium, manganese and boron supplies are discussed. After that the structure and function of the leaf as the organ of photosynthesis and evaporation are dealt with, and the basic types of cell respiration outlined. The handbook determines the rate of fertilization on the basis of the amounts of nitrogen, phosphate and potassium extracted by cultivated plants, and presents a table giving the recommended nutrient supply for field crops. The structure of the seeds and the generally applied methods of seed treatment are described from the point of view of practical crop growing. Seeds pelletized with fertilizers and fungicides are described in detail and recommended by the authors. Sowing times are given for Great Britain, with special regard to the grain crops. The data and yield averages of field crops (wheat, barley, oat, potato, sugar-beet, pea, horse-bean, carrot, fodder cabbage, rape, turnip, swede, maize) are given in general, and for the most important varieties in particular, on the basis of the FAO year-book (1972). Grassland management, which is carried out over 12 million hectares in the United Kingdom, is treated at great length. The harvested crop amounts to 2.5—15 ton/ha dry matter; the yield averages have considerably increased over the last ten years due mainly to fertilization and herbicide application. The botanical composition of grasslands, plantation by species or in grass mixtures, is discussed in connection with the papilionaceous plants (red clover, white clover). Apart from grazing, the crop from the grasslands is preserved in the form of hay or silage. Not only the techniques but also storage losses are presented. In addition to giving the yield averages for cereals, potato and sugar-beet and for green fodder plants, primarily for silage maize, the authors describe in detail the method and machines used in harvesting.

Finally, the authors consider the economic efficiency of crop production on the basis of the cost demands of mechanization and plant protection. The average data and evaluations refer to the United Kingdom.

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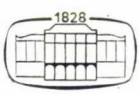

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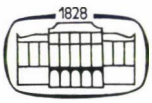

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